STRATEGIES FOR EFFECTIVE VALUE MANAGEMENT PRACTICE IN CONSTRUCTION INDUSTRY

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ABSTRACT

Value Management (VM) enhances project life cycle value through its application in both design and construction phases. VM is slowly being accepted by several governmental agencies, which is in contrast to the private industry's procurement of construction services where VM is less received. This dissertation explores the development of VM methodology through the joint use of a finite element software (Etabs) and genetic algorithm (GA) optimisation design to minimise the cost value of buildings by optimising structural elements. The objectives were to develop a new optimisation algorithm and apply the results to control construction project costs. The investigated VM methods involved conducting building value analysis in the design stage. To demonstrate the validity and efficiency of the proposed optimisation algorithm, various case studies were conducted in Malaysia. The results indicated that the proposed VM algorithm could improve building outcomes and support owners' control of project investment actively at the design stage, and improve the utilisation of funds more effectively. Additional techniques were also employed, namely a questionnaire survey (quantitative) and a series of interviews (qualitative). The survey included a demographic section regarding the respondent characteristics, and the VM section that asks about the application of VM at the respondent's workplace. Meanwhile, in depth interviews were conducted using an interview protocol on 25 respondents regarding details of VM applications amongst construction project teams. The quantitative data were subjected to descriptive statistical method analysis using statistical software, while the qualitative data were subjected to pattern matching methods, and cross-case and constant comparative data analysis. The outcomes of this research offer alternative perspectives for clients and construction professionals to have a better and deeper understanding about the constraints and strategies that exist to assist in the successful implementation of VM.

Keywords: value management, construction industry, genetic algorithm, optimization, cost.

ABSTRAK

Pengurusan Nilai (VM) meningkatkan nilai kitaran hayat projek melalui aplikasinya dalam fasa reka bentuk dan pembinaan. VM secara perlahan diterima oleh beberapa agensi kerajaan, yang bertentangan dengan perolehan perkhidmatan pembinaan industri swasta di mana VM kurang diterima. Disertasi ini meneroka pembangunan metodologi VM menerusi penggunaan bersama perisian elemen terbatas (Etab) dan algoritma genetik (GA) dalam reka bentuk pengoptimuman untuk mengurangkan nilai kos bangunan dengan mengoptimumkan elemen struktur. Objektifnya adalah untuk membangunkan algoritma pengoptimuman baru dan menggunakan hasil tersebut untuk mengawal kos projek pembinaan. Kaedah VM yang disiasat melibatkan analisis nilai bangunan dalam peringkat reka bentuk. Untuk menunjukkan kesahihan dan kecekapan algoritma pengoptimuman yang dicadangkan, pelbagai kajian kes telah dijalankan di Malaysia. Hasilnya menunjukkan bahawa algoritma VM yang dicadangkan dapat meningkatkan hasil bangunan dan menyokong pengendalian pemilik projek secara aktif pada tahap reka bentuk, dan meningkatkan penggunaan dana secara lebih efektif. Teknik tambahan juga digunakan, iaitu tinjauan soal selidik (kuantitatif) dan satu siri temuduga (kualitatif). Tinjauan tersebut merangkumi bahagian demografi mengenai ciri responden, dan bahagian VM yang menanya tentang pelaksanaan VM di tempat kerja responden. Sementara itu, temuduga mendalam telah dijalankan menggunakan protokol temuduga pada 25 responden mengenai butiran aplikasi VM di kalangan pasukan projek pembinaan. Data kuantitatif ditinjau oleh analisis statistik deskriptif dengan menggunakan perisian statistik, manakala data kualitatif dianalisis mengguna kaedah padanan corak, dan analisis data perbandingan antara kes dan berterusan. Hasil kajian ini menawarkan perspektif alternatif untuk klien dan profesional pembinaan untuk kefahaman lebih baik dan mendalam mengenai kekangan dan strategi yang ada untuk membantu dalam kejayaan pelaksanaan VM.

Kata kunci: pengurusan nilai, industri pembinaan, algorithma genetik, pengoptimuman, kos.

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TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF APPENDICES

LIST OF ABBREVIATIONS

VM	Value management
QS	Quantity surveyor
CIDB	Construction Industry Development Board
BIM	Building Information Modelling
CCA	Constant comparative analysis
EU	European Union
VE	Value Engineering
VA	Value Analysis
GEC	General Electric Company
IVM	Institute of Value Management
FA	Function analysis
PAQS	Pacific Association of Quantity Surveyors
EPU	Economic Planning Unit
AR	Action research
SPSS	Statistical Package for the Social Sciences
CAQDAS	Computer Assisted Qualitative Data Analysis Software
ρ^n	the ratio of steel bar to structural element dimensions at specified location n
DDI	Domestic Direct Investment
FDI	Foreign Direct Investment
MLT	Maintain Load Test
PDA	Pile Driving Analyser
PIT	Pile Integrity Test

CHAPTER ONE

INTRODUCTION

1.1 Background

The construction industry in Malaysia is one of the biggest industries contributing to economic sector towards improving quality of life in the society (Begum & Pereira, 2011). Construction projects include infrastructure works such as roads, dams, irrigation works, and socio-economic foundation such as schools, hospitals, airports, railways and factories. These are vital components in improving living standard and creating wealth through development endeavours that inevitably stimulates the nation's economy (Ibrahim et al., 2010).

Malaysian economy is developing rapidly and government has set target to achieve developed nation status in 2020 (Bakhtyar et al., 2013). Recent rapid economic growth in Malaysia has caused rise of housing demand especially in major urban areas and small towns in which dramatic increase of housing price can be seen. Housing prices increase naturally with other demographic and economic factors such as housing finance, inflation rate, construction cost etc., (San Ong, 2013). Figure 1.1 illustrates the Malaysia housing price index from 2000 to 2014. Values for subsequent years are measured as percentage increase over the base year.

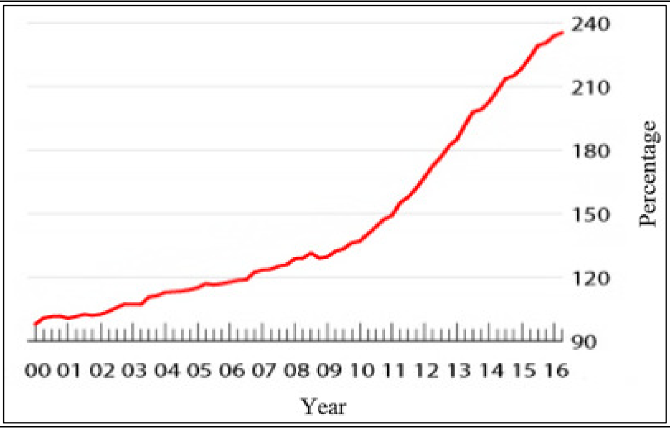

Figure 1.0.1
Malaysia house price index (JPPH, 2016)

Recently, Malaysian government is concentrating on the affordable housing for middle income population (Mousavi et al., 2013). Realising the uphill task to control the price increment, government imposed the Real Property Gain Tax (RPGT) again in January 2010 whereby any gain from the property that is sold within 5 years, will be taxed 5% of the selling price. In 2014 budget, government increased the RPGT up to 30% for property disposed by individual citizen within the holding period of 5 years and gradually decreased to 20% and 15% in the fourth and fifth years respectively (Mohd Isa, 2014). Figure 1.2 illustrates the percentage of change of Malaysia house price over a year earlier.

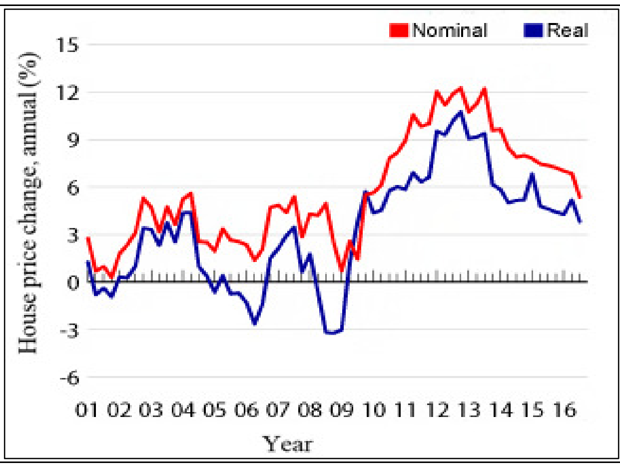

Figure 1.0.2
Malaysia house price; Percentage of change over a year earlier (JPPH, 2016)

In addition, the structural and building design in Malaysia also contributes to high cost of construction. Cost overrun is a serious problem in construction industry, which can cause investment pressure, increase construction cost, affect decision making, and waste taxpayers' money if corruption involved. Particularly, when a project becomes more technical and complicated or larger, it is necessary to put proper coordination of human effort and physical elements to suit the restrictions such as scope, cost, time and quality (Ali & Kamaruzzaman, 2010). A number of developed countries have used the models in estimation construction waste depending on the environment and suitability, however the model of estimation is still lacking in Malaysia (Hasan et al., 2013).

Within the last decade Value Management (VM) has been accepted as an emanating paradigm that aims at continuously raising the value provided to the client. VM has also been recognised as a key mean in the successful management of construction projects (Ellis et al., 2005). A number of countries around the world have reported the successful applications of VM in the construction industry, (Norton & McElligott, 1995), and achievement of 'best value' for clients, (Kelly et al., 2009), through providing a structured methodology via specific supporting tools that assist effective decision-making on many types of projects. According to Qiping Shen and Liu (2003), many research works have been directed towards new tools and methods in VM. The value of functional analysis was mentioned to be very well contributing in success of VM studies and therefore it was strongly emphasized by a number of influential VM researchers (A. J. Dell'Isola, 1966; Zimmerman & Hart, 1982). This was challenged by Qiping Shen and Liu (2003) in citing Palmer, Kelly and Male (2003) who argued that this contribution of functional analysis is the sole factor to VM success and believed that the VM seminar with the prescribed multidisciplinary team participation is a critical factor.

There is no doubt that VM application will result in reduction of the wastes and improvement of the efficiencies. Furthermore, VM serves as a practical, innovative and problem-solving technique and targets the advancements in a project's value via functions analyses. By benefitting from structured systems and interdisciplinary assessments, it has become a systematic, function oriented decision making tool (Whyte & Cammarano, 2012). It is widely accepted that the VM process is an operational effective approach in reducing the redundant investments and life-cycle costs. However, the proper way of applying VM is less known.

VM was introduced in Malaysia in 1986 for the first time (Jaapar, 2006; Jaapar et al., 2007) and currently some client organisations are seen in Malaysia applying some concepts of VM in their projects (Che Mat, 2002; Jaapar et al., 2012; Ong & Yeomans, 2002; Tamim, 2002; Yahya, 2003). Application of VM in Malaysia is in its infancy and so far it has not become widely practiced in the Malaysia (Jaapar et al., 2009; Jaapar & Torrance, 2005) while in other developed countries like USA, Japan, European countries, and Australia it is widely accepted. In order to promote the application of VM in the Malaysian industry, first it is crucial to know about the status of VM application and second, a system of VM philosophy should be created which suits the current local scenario.

Malaysian construction industry has experienced some successful applications of VM so far and that calls upon the demand of respective actions to be taken to exert its full potential to increase value for money. Che Mat (1999) argued that VM does not just consider the cost but it investigates the relationship between quality, value, cost and function in a wider perspective and eliminates the unnecessary cost which has no contribution to the project's value, system and facilities. This leads to a fundamental contribution of VM application and therefore, clients' understanding towards the VM concept is an important issue. Thus, it is crucial to promote the sustainable VM applications in the future of Malaysian construction industry.

This research is looking for the solutions to enhance the industry's future practice and to propose practical methods to apply VM in design stage and generate workable frameworks for the construction industry. Implementation of VM is a challenging task because of consultants' preference for using conventional design process due to lack of understanding of its philosophy and application.

1.1.1 Value Management in Design

One of the areas associated with application of VM is the way engineers look into the design and it is called design approach. The best and effective ways to reduce construction cost is by minimising the wastages through optimised design and construction methods (Arif et al., 2013).

Overdesign is defined as to design such unnecessarily complicated or surpassing normal standards for the strength and safety. Overdesign of structural elements is more difficult to control as designers will have to abide by the design code. The early design phase is the most important phase for design management in architecture, engineering, construction and it has to be managed effectively and efficiently (El. Reifi & Emmitt, 2013). Design experience needs time and proper training and any young engineer requires years of training to become an expert in engineering practices.

Mistakes by the incompetent designer cause poor design and drawing and thus the development turns into questionable quality particularly for those involved in government projects. Any changes in design after the construction started will lead to increase in cost and time (Ali & Kamaruzzaman, 2010; Le-Hoai et al., 2008).

Computerised design software which is currently available in the market is utilized by most of structural engineers to design structural models. These software packages however are not programmed to produce optimal design output. Normally, design software generates the design analysis, design calculations, structural reinforcements and other documents. Every engineering software package is different in terms of analysis, calculation and drawing output. However, from the author's experience, exceeding designs are not always notified, and it is observed that most structural engineers do not really bother in finding optimum balance of the overall designs. Consequently, most of the structures are overdesigned and not thoroughly checked of their optimisation in terms of strength to the loads applied. Most consultants practice conservative structural designs and they do not want to take risk. As a result, most developers do not consider VM for their developments. It is observed that some calibration on the software is needed to obtain an optimum design. This is especially important when the design is based on codes from other countries.

VM has increasingly turned into an important approach in the construction industry to positively affect construction projects. “VM practices have been widely applied to major projects, but mainly in design and procurement but only in the early stages of construction”, (Kelly et al., 2014). The objective of VM is to attain improved cost effectiveness without compromising reliability, quality and safety requirements and function and performance. “The VM principles and methodology provides a systematic approach in searching for alternative solutions that preserve the functionality and reliability of constructed facilities”, (Cheah & Ting, 2005). These elements can lead to the deletion of such unnecessary costs.

Although research in VM towards elimination of unnecessary cost and to increase the value of the money expended is on demand however, for the time being there is no published evidence that VM in Malaysia is being efficiently implemented. “Market trends show that there is a rising competition in the construction industry” (Ramli et al., 2013). It is also anticipated to motivate the desire for more cost-effective investment by both developers and clients to lessen their exposure to financial risk. Therefore, VM is looked as an important mean for construction projects in Malaysia. This is particularly pertinent in times of recession, when value for money is of prime importance.

VM reduces the usage of materials and consequently the construction cost, which allows cheaper home to be built. Developers as the clients can share the saving with consultants whereby they consider the sharing as fee. This way, consultant will be motivated to apply VM and reduce the costs. The latest method in designing efficient building is by using Building Information Modelling (BIM) which is the growing application that can integrate all the building designs under single software. By using BIM consultants can reduce clashes between architectural, structural, mechanical and electrical elements and therefore minimise the wastage. Result from survey by Salleh (2007) showed that the civil and structural consultants believed that the computation of the scale of fee by BIM is tedious and is based on the engineering content. Hence, many of them agreed to any proposal to revise the scale of fee. Engineering consultancy business also has high overhead cost needed such as professional and semi-professional workers, and other technical staff and office upkeep. Some engineers also feel that more man-hour is needed for engineering design work such as studying the plan, producing structural design, performing analysis, coordinating drafting works, and conducting meeting and, as compared to other profession, even for the architect.

1.2 Background and Problems

Successful applications of VM in the construction industry have been observed in a number of countries around the world (Norton & McElligott, 1995). VM has proven to provide a structured methodology using specific supporting tools and techniques that facilitates effective decision-making on many types of projects, thus achieving ‘best value’ for clients (Kelly & Wilkinson, 2002). Shen and Liu (2003) report that much focus has been directed into researching new tools and methods in VM. A number of influential VM researchers have placed strong emphasis on the value of functional analysis, which is considered to be an indispensable factor contributing to the success of VM studies (Dell'Isola, 1982; Zimmerman & Hart, 1982). However, Shen and Liu (2003) in citing Palmer, Kelly and Male (1996) challenged the contribution of functional analysis as the sole factor to VM success and argued that the VM seminar with the prescribed multidisciplinary team participation was also a critical factor.

However, throughout the literature, much of the VM research on seminars, tools and techniques and multidisciplinary team participation focuses on their efficiencies and effectiveness (Leung, Chu, & Lu, 2003). Research into the specific functional roles of individual participants (i.e. the human aspect) in VM studies, and into alternative techniques used to assist VM studies, are relatively limited to date (Singh & Jannadi, 2006). This omission calls for an expansion of research into the contribution of the human aspect to decision-making and levels of participation as important critical factors contributing to successful outcomes of VM seminars Palmer et al. (1996). The phenomenon of particular professions conducting VM as part of their consultancy services has been observed by several researchers (Bowen, Edwards, Cattell, & Jay, 2010; Bowen, Edwards, & Catell, 2009; Bowen, Edwards, Catell, & Jay, 2009; Ellis, Wood, & Keel, 2005; Ellis, Woods, & Keel, 2003) including the effect on team dynamics and facilitation styles (Hunter & Kelly, 2006; Kelly, Male, & Graham, 2004; Male & Kelly, 2004; Yeomans, 1997). The research of Leung et al. (2003) on the participation of individuals and groups in VM seminars is considered as a pioneering study in exploring in some depth the behavioural aspects of participants in VM studies and seminars. Their findings have uncovered another dimension, i.e., human attributes as being a further critical VM success factor.

Therefore, this research is directed at expanding previous studies the human aspects of, and specifically explores the influences and impacts of multi-disciplinary participants on, the creative and decision-making processes of VM seminar conducted during the planning and design stages of a construction project. In addition, not many engineers have done research about VM and its practical application in real construction project. Therefore, this study provides real assessment to the current practices in VM that can be practically applied to construction project.

1.3 Research Question

In order to demonstrate existence of a weakness in design and build systems, exclusively associated with coordination during the design stage of a project when the contractors' early involvement is anticipated to cause more effective achievement of project objectives, several research questions are desired to be considered;

(i) What are the current design practices in Malaysia which contribute to the high cost of construction?

(ii) What are the perception of industry players on VM that leads to lack of VM application in Malaysia?

(iii) What are the crucial subjects involved in the design stage of projects that mostly lead to final costs exceeding budgets?

(iv) How does the VM application during design stage assist in addressing issues pertaining to value-adding and cost optimization to client's existing needs?

1.4 Research objectives

Based on these research questions the research objectives can be established as follow:

(i) To develop a new VM optimization algorithm for optimal design of structural members in practice and factors that contributed to unnecessary cost of constructions.

(ii) To determine the perception of VM amongst industry players that leads to lack of VM application in Malaysia.

(iii) To establish a framework that can be a guideline for VM application in Malaysian construction industry.

(iv) To investigate how the proposed VM algorithm can be applied to actual project constructions to clearly analyze the relation between their function and cost, which explore the performance of the proposed algorithm in effectively reduceing the project cost.

1.5 Scope of research

The purpose of this study is to investigate the application of VM theory, and how this works in practice during the early stage of construction project, especially in design stage. The research will apply a mix of quantitative and qualitative methodologies. The qualitative method was conducted in this research as it provides the base for the subsequent data collection. The quantitative method is utilized to support further in-depth exploration of the issues of interest in the research. For quantitative part, a survey was done on the application of VM in Malaysian construction industry. The survey was divided in two parts; the first part is the demographic study and the second part uses Likert survey method to survey the VM application in their workplace. The short questionnaire was given to the attendee of Seminar on VM. Literatures mostly referred to electronic sources by accessing national and international journals, scientific articles, etc.

This dissertation initially is built upon study and discussion of the philosophy and phenomenon of VM, decision making, design organization constraints, project team operation and client value systems. These issues will be integrated to clarify and focus on the potential benefits of applying VM as a technique which facilitates decision making associated with cost optimization and value adding in construction projects.

Optimization of structural design is a critical and challenging task that has received professionals' attention in the last few decades. Designers create improved designs along with considerations of saving money and time through optimization. Traditional design methods encompass various mathematical techniques such as linear, nonlinear, and dynamic programs. These techniques have been developed to deal with engineering optimization issues. However, these techniques represent a limited approach, and no single method is totally efficient and robust for all kinds of optimization problems. Hence, the computational intelligence techniques such as the genetic algorithms, with excellent capability in pattern recognition, also have been taken into this study to deal with the complexity of optimization problem.

1.6 Significance of research approach

The author has many years of experience in saving millions of ringgits in construction cost through VM. Author has observed that most structural engineers and designers are conservative in their structural designs and this has led to unnecessary spending of clients' and taxpayers' money in building and construction projects. The author has 30 years of experience in engineering consultant and has helped many clients in saving the construction cost through VM designs, but surprisingly until today not many engineers are practicing the VM concept or even aware of its application and benefits.

Apart from engineers who are still comfortable with conventional design, there are other reasons why engineers are reluctant to change such as;

(i) No incentive or immediate monetary benefit in practicing VM.

(ii) VM will reduce the construction cost and eventually reduce their consulting fees.

(iii) No understanding of the VM concept and design- Lack of experience and knowledge.

The Malaysian construction has been contributing significantly to the economy sector and consequently has been appointed to research location in terms of geographical factor and researcher's knowledge of the sector. Since 2009 to 2011 this sector has contributed an average of 3.3% to the Malaysian GDP (Construction Industry Development Board (CIDB) Malaysia, 2013). Although positive responses from the majority of experts in the construction field portend application of VM in construction industry however, VM is not really well known in this country. Most of the participants in VM seminar are Quantity Surveyor (QS) and lecturers. Structural consultants may practice VM informally through collaboration with contractors and client, but VM practice and outcome are not formal through these methods and normally harder to track the saving and determine the value. Jaapar et al. (2009) suggested that understanding the current practice of VM application in Malaysia is crucial before developing a proper VM philosophy to suit Malaysia construction industry.

Not many engineers have done research about VM and its practical application in real construction project. Most engineers don't have the experience in applying VM. Hence, this research provides real world assessment to the current practices in VM and proposes significant enhancement through framework that can be practically applied to construction project.

1.7 Thesis Outline

This thesis comprises five chapters and is organized as follows:

Chapter 1 introduces and presents the background, problems, research objectives and application for construction industry in Malaysia and outline of the thesis.

Chapter 2 discusses the background of VM, definition, history, VM job plans, the methodologies and VM application for Malaysia.

Chapter 3 outlines the research methodologies for this research. The adopted mixed methods including the quantitative and qualitative approaches are discussed with respect to the objectives of this research. Moreover, to optimize the structural elements and control investment of construction project a VM framework is proposed in this chapter.

Chapter 4 presents in-depth discuss of the quantitative and qualitative analyses of the data collected. The quantitative approach in this chapter analyses the survey data gathered from respondents and takes advantage of descriptive analysis technique. The latter involves analysis of interview transcripts, using Constant Comparative Analysis (CCA). Finally, the result and analysis of the practical case studies based on the proposed VM algorithm is assessed.

Chapter 5 discusses the conclusion and recommendations including a summary of the key findings, the methodological settings and analysis, and contribution to the VM.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

The review of the literature for this research is consist of two parts. The first part emphasized that on concept of value management while the second part focused on building design planning and processes. Literatures on the VM concept will be reviewed with purpose to figure out the VM function in design project. The review will be concentrating on the description of value management, phases of VM, methods and tools in cost control of construction project, application and current practices by region.

2.2 Value Management Definition

Value Management (VM) is defined as a thorough and organised effort to achieve maximum value of a product or services while minimising the cost of project without forfeiting the required quality, safety, reliability and life cycle cost of a project and performance by working together in achieving client and stakeholder needs (Chung et al., 2009; Shah & Bina, 2006). It also defined as structured approach that working on evaluating the function, tools, amenities, services and materials with the aim of getting the functions work at smallest life cycle cost without scarifying the performance, consistency, quality and security (M. D. Dell'Isola, 2003).

VM is a management concept which has been embrace internationally especially in construction industry, where it can increase the value of products for the client. It can be achieved by focusing on the customer requirement by conducting function analysis study. Through a series of methodical procedures, clients are able to find cost value for both short and long term investment using various tools like functional analysis, risk analysis and depending on cooperation and ingenuity combined together with precise cost assessment (Jaapar et al., 2005).

Jaapar et al. (2009) described VM procedures encourages the change in mind set of the organisation where it makes easier to achieve value culture for the client and can be summarised as a goal setting process to reach clients' expectations and improve relationship. In VM application, the client is expected to set bench mark of the qualities and performance, while the designers and contractor are expected to deliver them.

In addition, VM is a team oriented methodology used to managing and deliver product, service and project with minimum cost and maximum performance without reducing the quality (Steven Male et al., 2005). Although naturally good designers will try to surpass the client's expectations, with the idea of making better quality elements will automatically give better value, even though that may not be true because of relation between cost and value is not linear. VM has expanded its application to the softer context of value proposition where other important values such as environmental, social, stakeholders, system and quality rather than economical or monetary only (H Ong, 2003).

European Union (EU) described VM as a management concept that committed in encourages people to enhancing the skills and working together with innovation in mind to achieve the maximum performance in an organisation (H Ong, 2003). Furthermore, the VM is defined as a concerted effort to achieve maximum value of a product, system or services through granting the main function at the cheapest cost. In construction industry, Al-Yami and Price (2005) described the used of Value Engineering (VE), Value Analysis (VA) and Value Management (VM) in examination structured process of the function of the building to ensure that it is delivered in the most cost-effective way.

In construction application, the term VE, VA and VM used to describe the process of value Methodology of the structured and sequential process of classifying the functions of building or facility in ensuring the construction will be done in accordance to the principal of value enhancement and cost-effective ways. However, the term VE, VA and VM are distinct from each other although the objective is the same where VM is a management style used in corporate level and VA/VE is consider as a tool applied in project and operational level (Cheah & Ting, 2005). It is conducted by a multi-disciplinary team consists of experienced and specialized professionals who are working as an extension of the design team. Steven Male et al. (2007) concluded that VM is a management approach that concentrated on value and organisation systems by bringing right stakeholders together.

2.3 Value Engineering Background

Value Engineering was established in the manufacturing sector of North America and value thinking began in the late 1940s when the shortages of strategic material forced, initially General Electric Company (GEC), to consider alternatives which performed the same function with the lowest cost (Dallas, 2008; Hayden & Parsloe, 1996; Kelly & Male, 2003; B. R. Norton & McElligott, 1995; Sik-wah Fong, 1999; Zimmerman & Hart, 1982). It was soon found that many of these alternatives provided the same or better quality at a reduced cost, which led to the first value analysis definition, being: "value analysis is an organised approach to providing the necessary functions at lowest cost" (Kelly & Male, 2002).

The important VE milestones can be found in Younker (2003). However, Zimmerman and Hart (1982) stated that VE was first used in the USA construction industry from

1963 to 1965 by the General Services Administration, when a contractor's sharing clause was added to construction contracts.

In the same decade (1960s), VE started in the UK manufacturing sector which led to the establishment of the Value Engineering Association in 1966. In 1972, the name of this organisation was changed to the Institute of Value Management (IVM) (Kelly & Male, 2002).

The term VM is the common name in European countries to describe the service. In the UK construction industry, VM became popular in the early to mid-1990s (Kelly & Male, 2002). In their benchmarking (comparing (Eaton, 2002)) study, Steven Male (1998) attributed the spread of VE globally to activities of American practitioners and multinational manufacturing companies. Furthermore, VE went to Australia in the 1960s via the multinational companies as well. In Germany, the Value Society was established in 1974, and in 1978 in France. Japan, India and South Korea adopted the SAVE International model of practicing and certification. In addition, Fowler (1990) stated that in the early 1960s Japan picked up VA, and each organisation there now has a value analysis system. However, Dallas (2008) argued that the focus of VM has been changing over time and this can be seen in Figure 2.1.

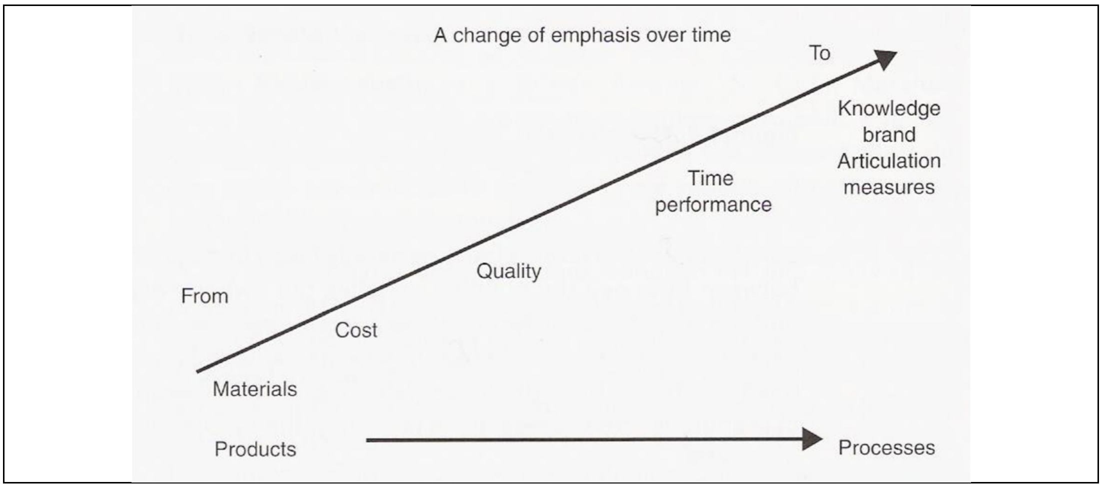

Figure 2.1
The evolution of VM (Dallas, 2006)

Having reviewed the VM history, the next stage is to explore its associated terminologies to identify which one is used for this research.

2.4 Value Management Terminology

Kelly and Male (2003) have adopted the term VM instead of VE since the former has spread and is used throughout Europe as well as being used by the European community in its strategic programme for innovation and technology transfer as an important business procedure. VM and VE are the most commonly used terms in the literature. Nevertheless, there are other terms in use such as value analysis (VA), value planning (VP), and value methodology (this is the name of value management in the USA) (Kelly et al., 2014). However, VM is the most acceptable term for the UK construction industry (SP Male & Kelly, 1998). Connaughton and Green (1996) described the relationship between VM and VE as VE being a special case of VM (as indicated Figure 2.2). Furthermore, Hayden and Parsloe (1996) mentioned that VE is usually considered a subgroup of VM. Moreover, OGC (2003, 2007) supports this view by stating that VE is a part of VM that considers specific aspects of design, construction, operation, and management. Kelly et al. (2014) argued that, strategic and organisational issues are the VM domains while the technical issues including space, elements and components are the VE preserve. However, Hammersley (2002) argued that VM is used to get the right project whereas VE is done to get the project right.

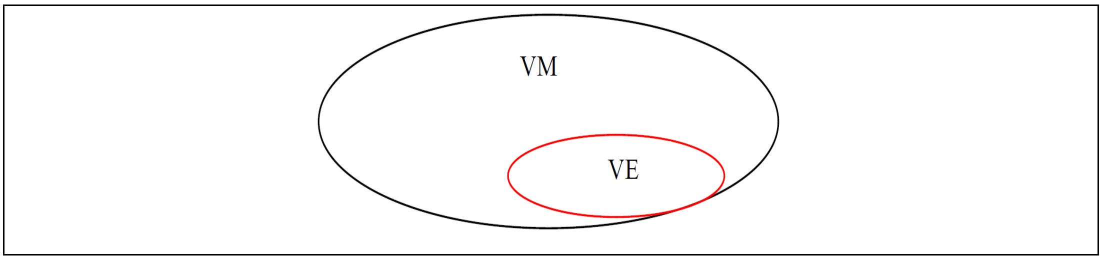

Figure 2.2
VM and VE relationship (Connaughton and Green, 1996; Hayden and Parsloe, 1996)

Sik-wah Fong (1999) argued that VM is one of the most misunderstood management concepts and this is because of the various terminologies. Woodhead and Downs (2001) cited by (Hunter, 2006) supported this when they found that a common criticism of VM was the jargon associated with it. They mentioned that "value is defined by the context in which it is used" and they named this as 'Value Ecology'. Furthermore, they argued that the dominant paradigms in the VM study situation would identify what value is in order for VM to improve it. Therefore, VM is a methodology to be adapted to the environment of the study and the values of significance to the owner (Hunter, 2006). Some people might use different terms and therefore, the value manager should become familiar with the terminology that is used in the organisation within which he is working so that he uses the terms that are suitable for people in this organisation (Dallas, 2008). However, as this research focuses mainly on strategic issues in Malaysia construction projects, VM is adopted because it is considered the most appropriate one for that.

2.5 Value Management Features

VM does not have any universally accepted definition and characteristics (S. D. Green & Liu, 2007). Therefore, it should be defined and characterised in the context of this research as follows.

There are many definitions which exist for VM. However, the VM framework's definition is used for this research as it was developed from an international benchmarking exercise and it addresses the concept of value through Function Analysis (FA) by defining VM as: 'a proactive, creative, problem-solving or problem-seeking service which maximises the functional value of a project by managing its development from concept to use. The process uses structured, team-oriented exercises that make explicit and appraise existing or generated solutions to a problem, by reference to the value requirements of the client' (Steven Male, 1998). Although this definition focuses on the project, the BSI (2000b) definition indicates that VM should be applied at different organisational levels to improve value for money and performance to the whole organisation and therefore, it is not limited to projects.

Additionally, there are many features, which can be associated with VM. In this section, they will be summarised as follows. VM could apply to the value process study during the whole life cycle of the project or at any stage from concept to operational stage (Chapman & Ward, 2008, 2004). It is not about getting the project right but rather, about gaining the right project (Hammersley, 2002).

In order to clarify its features, VM is a system oriented and multidiscipline team approach; life cycle oriented; a proven management technique; function oriented. On the other hand, it is not: a design review; a cheapening process; a requirement done on all designs; a quality control; a cost reduction exercise; standardisation exercis (Leeuw, 2001; Zimmerman & Hart, 1982). There is confusion between VM and cost reduction exercises; while their procedures have some similarities, the methodologies, aims and outcomes are different (Hiley & Paliokostas, 2001). VM is much more than a cost reduction technique (Phillips, 2002). Cost reduction aims to gain the lowest total cost of the project, even if this means a sacrifice in value (B. Norton, 1992) cited by (Hiley & Paliokostas, 2001). However, VM differs from cost reduction in certain key points, as some scholars have already highlighted (Commerce, 2007; Connaughton & Green, 1996; Treasury, 1996):

(i) VM is positive, focused on value rather than cost. Furthermore, it aims to balance time, cost and quality;

(ii) VM is structured and accountable;

(iii) VM is multi-disciplinary. Moreover, it aims to maximise the creative potential of all departmental and project participants working together.

Kelly et al. (2014) concluded that the value system, team-based process and FA are the core features that distinguish VM from other management services. Regarding the previous point mentioned, value management is not only for reducing cost but also about function and optimum value for money even if that means increasing the cost of the project. It is an ongoing process, and usually it is better to make a periodic review of customer needs relative to project aspects.

2.6 Purpose of Value Management

In competitive environment, clients have become more assertive and demanding thus has higher expectations from consultants and contractors in term of financials and economic benefits (M. D. Dell'Isola & Demkin, 2003). Therefore, VM application is used to ensure that project is delivered in the most cost-effective way, focusing on safety and long term protective measures for client's benefit where the application can contribute in millions of saving and will simplify project management (Al-Yami & Price, 2005).

A. Dell'Isola (1997) as cited in Al-Yami and Price (2005) described the VM objective is to shorter the time frame, better quality and reliability, easy maintenance and increase performance. VM can be an agent of change for working attitude, like enhancing creativity and foster teamwork, optimising the use of capital, manpower and materials.

Jaapar et al. (2009) described VM procedures encourages the change in mind set of the organisation where it makes easier to achieve value culture for the client and can be summarised as a goal setting process to reach clients' expectations and improve relationship. In global stage, VM is a management model that always strives in maximizing the value to the customer and increasingly accepted as important instrument of construction management project as mentioned by Ellis et al. (2005) as cited in Jaapar et al. (2009). Since introduction into construction industry, VM has always been considered as cost saving tools where VM practitioner are focusing on VE aspect of VM through FAST diagram, and structural evaluation (Hamid et al., 2011).

2.7 Value Management Application

Value management basic principal is primarily to give better value for the product, service, system or project and to eliminate the redundant cost which does not contribute to the function and purpose therefore keeping or adding value which usually translated into monetary term (H Ong, 2003). It can be most effectively applied in planning and design stage because the later application during the construction stage will increase the cost greatly. VM can be done through three main stages which are planning and design; construction and maintenance and operation. VM was formally applied in manufacturing sector where it focused in improving product, facilities and project before spreading into construction industry (H Ong, 2003). However, solution through VM often did not well received due to lack of clear guidelines and measurement quantification, method of evaluation and exaggerates opinions by VM proponents (Chung et al., 2009). VM application needs persistence, attentiveness and proper arrangement from the participants and they have to have mutual understanding by working together to achieve the intended goal (Dell'Isola & Demkin, 2003).

The VM team analyses the project from a function/cost standpoint, providing alternative designs that may improve performance, construction and life-cycle costs. They may also improve construction methods or schedules, and may introduce flexibility into operating or maintaining the project. Contractors and consultants are expected to give a clear cut budget plans, deliver design and construction that have quality and performance, and giving more value to the scope and budget of the project (Dell'Isola & Demkin, 2003). Master Builders Association of Malaysia (MBAM) has implemented a "group quality scheme" using Value Managed Quality System (VQMS) to comply with ISO 9001:2000 quality standards to be adopted by contractor and subcontractor in Malaysia to deliver the quality products of building and construction projects (Ong, 2003). Che'Mat and Shah (2006) described the relationship between Value, Function (Worth), Quality and Cost can be represented as below:

$$\frac{\text{Function+Quality}}{\text{Cost}} \tag{2.1}$$

where "Function" is the specific worth that a design/item must perform, "Quality" is the owner's or user's needs, desires and expectation, and "Cost" is the life cycle cost of the product/project.

The VM can be included in the project management team and later to design team which can be very beneficial methods or process to find solutions of the problem, to reduce cost, optimizing functions and increase value (Dell'Isola & Demkin, 2003). VM which has been properly applied brings order to value system and to ensure project conducted efficiently and effectively and delivered successfully will cost dearly to redo the process (Male et al., 2007). Jaapar et al. (2009) conducted a survey which aims to examine the benefit of VM for Malaysian construction industry and to investigate the current level of VM practice in Malaysia. It is observed that the more experiences the respondents were in the industry, the higher probabilities they are exposed to VM which roughly made 78% respondents aware on the VM but only 16% of respondents are well verse on the terms and have attended courses. It is discovered that 51% of the respondents did not practice VM, despite 99% of the respondents agreed that VM application is viable for Malaysian construction industry and majority of the projects which had applied VM were valued in between RM11 to RM50 million. It is found that 18% of respondents were extremely satisfied and 60% were satisfied with the result of VM applications; where 52% of 149 projects which applied VM recorded saving of 10% from the initial costs and 25% managed to save up to 30% of the initial costs. The results also shown that the respondents' favourable view of VM application is because of the ability in reducing unnecessary costs, adding better value to the project and giving better functionality.

2.8 Evaluation of factors affecting cost performance in building projects

Chan and Kumaraswamy (2002) remarked that studies in various countries appear to have contributed significantly to the body of knowledge relating to time performance in construction projects over the past three decades, while Iyer and Jha (2005) remarked that project performance in term of cost is studied since 1960s. These studies range from theoretical work based on experience of researcher on one end to structured research work on the other end. Moreover, Pheng and Chuan (2006) stated that there have been many past studies on project performance according to cost and time factors. Chan and Kumaraswamy (1996) stated that a number of unexpected problems and changes from original design arise during the construction phase, leading to problems in cost and time performance. It is found that poor site management, unforeseen ground conditions and low speed of decision making involving all project teams are the three most significant factors causing delays and problems of time performance in local building works. Okuwoga (1998) stated that cost and time performance has been identified as general problems in the construction industry worldwide. Dissanayaka and Kumaraswamy (1999) remarked that project complexity, client type, experience of team and communication are highly correlated with the time performance; whilst project complexity, client characteristics and contractor characteristics are highly correlated with the cost performance. Reichelt and Lyneis (1999) obtained that project schedule and budget performance are controlled by the dynamic feedback process. Those processes include the rework cycle, feedback loops creating changes in productivity and quality, and effects between work phases. Chan (2001) identified that the best predictor of average construction time performance of public sector projects in Malaysia is T = 269 C 0.32 . This relationship can serve as a convenient tool for both project managers and clients to predict the average time required for delivery of a construction project. Kuprenas (2003) stated that process of a design team meeting frequency and the process of written reporting of design phase progress were found to be statistically significant in reducing design phase costs. Otherwise, the use of project manager training and a project management based organizational structure were found to be processes that do not create a statistically significant in reducing design phase costs. Iyer and Jha (2005) remarked that the factors affecting cost performance are: project manager's competence; top management support; project manager's coordinating and leadership skill; monitoring and feedback by the participants; decision making; coordination among project participants; owners' competence; social condition, economical condition and climatic condition. Coordination among project participants was as the most significant of all the factors having maximum influence on cost performance of projects. Love et al (2005) examined project time-cost performance relationships by using project scope factors for construction projects that were completed in various Australian States. It is noticed that gross floor area and the number of floors in a building are key determinants of time performance in projects. Furthermore, the results indicate that cost is a poor predictor of time performance. Chan and Kumaraswamy (2002) proposed specific technological and managerial strategies to increase speed of construction and so to upgrade the construction time performance. It is remarked that effective communication, fast information transfer between project participants, the better selection and training of managers, and detailed construction programs with advanced available software can help to accelerate the performance. Jouini et al (2004) stated that managing speed in engineering, procurement and construction projects is a key factor in the competition between innovative firms. It is found that customers can consider time as a resource and, in that case, they will encourage the contractor to improve the time performance.

2.8.1 Cause and Effect Diagram

The Cause and Effect Diagram, also known as “Fishbone” or “Ishikawa Diagram,” is a categorical brainstorming graphic tool used for determining the root-cause hypothesis and the potential causes (the bones of the fish) of a specific effect (the head of the fish) (Munro, Maio et 17 al. 2008). Cause and Effect Diagrams can help teams to focus on the problem itself and not on the history of the problem. Also, Cause and Effect Diagrams can aid in focusing the team members on the roots of the problem and not prescriptive symptoms. Figure 2.3 presentes a cause-and-effect diagram. Causes of delay are mainly due to procurement, money, methodology and related manpower. Each cause has sub-causes which may be related to one another. The intention of the diagram is to identify probable causes for schedule delay.

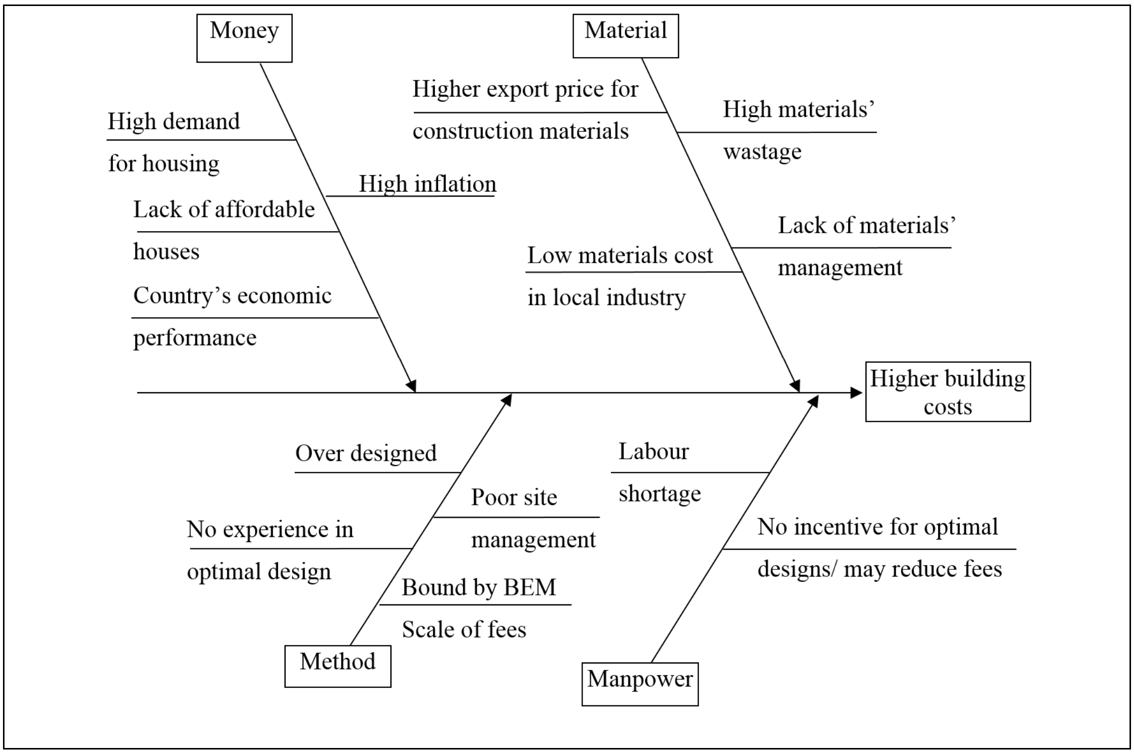

Figure 2.3
Cause and effect diagram in relation to higher building cost

2.9 Value Management in Design Process

VM is a service that takes place at the front end of a project where the primary emphasis is on making explicit the client's value system through the use of functional analysis and other problem solving tools (Kelly & Male, 2003). It has been recognized as one of the most effective methodologies for achieving "best value-for-money" for clients since its introduction into the construction industry in the early 1960's (Qiping Shen & Liu, 2003). The evolution from the manufacturing industry, which initiated VA in 1940's, and first applied in the construction industry in 1963 (Dell'Isola, 1982) has attracted interest from many sectors of the construction industry across the world (Fong & Shen, 2000). The UK has already seen a substantial growth in the development and practice of VM, mainly in the construction industry, since the introduction of VE to the UK in the 1980s. As reported by Q Shen (1995), in 1988 RICS published "A Study of VM and QS Practice", by Kelly and Male, which illustrated the practice as used in North America, and proposed the benefits and potential of using VM in the UK, particularly to the quantity QS profession. The publication marked the beginning of the serious development of VM as a tool to be used in the construction industry to achieve better value for money.

According to Kelly et al. (2014), VM is distinguished from other management processes by three primary core elements: i) establishment of a value system; ii) building a team-based process iii) use of functional analysis to promote in-depth understanding. These core elements provide a holistic approach to reviewing and solving construction project issues through a more systematic approach. Ashworth and Perera (2015) claims that the main purpose of VM is to reduce unnecessary costs as projects can be designed and constructed in many different ways and each different design attracts particular costs. Where two different designs satisfy the main client requirements, then the difference between the costs of these designs can be described as an unnecessary cost. However, Kelly and Male (2003) argued that the total economic management of projects involves considering both cost and value. The latter encompasses cost but also takes account of the subjective decision-making criteria of the client organization in perceiving what are acceptable levels of project performance and technical specification. Eliminating unnecessary cost alone does not contribute to the entire goal of VM which is the achievement of better value for money.

Within the context of early design, VM is perceived primarily as an aid to the briefing process rather than a technique of cost reduction (Kelly et al., 2014). The design process is perceived as a never-ending cycle of action research which continues until designers run out of time. Design is therefore a learning process comprising endless cycles of planning, action and evaluation of all aspects that require consideration. The activities of briefing, designing, constructing and post-occupancy evaluation contain many such cycles within themselves.

Pacific Association of Quantity Surveyors (PAQS 2010) Conference, Sentosa Island, Singapore Green (1994) stresses that VM makes no pretence in finding optimal answers; however, it concerned with establishing a common decision framework around which the design team can think and communicate. Constructing a shared perceived reality is the key driving factor in VM which is oriented through team-based approach in design. As a project progresses, the client and stakeholder involvement changes from making strategic decisions, to undertaking routine, operational project decisions. Their roles are typically reduced to agreeing the design decisions of their professional project team. The relevance of VM in involving stakeholders in all design decisions therefore diminishes with project progression. These further transfers the design decision to the professional consultants solving technical problems which requires the combined effort of the multi-disciplinary team.

In relation to solving problems in design, Green (1994) advances the idea of 'hard' versus 'soft' systems thinking, where the former is predominantly concerned with the identification of optimum solutions to known technical problems, whilst the latter is concerned with determining multi-perspective human problem situations. The combination of both types of systems thinking is crucial in delivering a building which serves not only the client requirements but also those of the end–user. Although it may be argued that one type of systems thinking is more important than the other, the underlying principle at stake lies in defining what the actual project function is to be by the end of the day. Therefore, VM is used to develop a common understanding of the design problem, to specify the design objectives and to synthesize a team consensus about comparative methods and alternative courses of action based on the problem identification (Green, 1999; Leung et al., 2003; Leung & Liu, 1998). The inclusion of multi-disciplinary teams in VM studies provides a strong foundation for clearly defining design issues that address or involve construction cost optimization. It ensures that the decisions made are balanced, explicit and accountable. Leung et al. (2003) has further suggested that participation of all team members is an important element of the construction project in terms of assisting experts in getting the best value for the project. Participation leads to commitment, which in turn leads to ownership. The spirit of ownership is fundamental in this research which forwards the idea of greater contractor involvement during the design stage to assist in cost optimization. The role of contractor is perceived to contribute greater opportunities for cost optimization through transfer of shared knowledge of construction technology during the design stage of a project. This idea further extends the work of Green and Liu (2007) and Fan and Shen (2011) on the use of group-decision support systems in VM which examines the potential contribution made by the contractor as part of the team.

2.10 Value Management Application in Malaysia

The concept and application of VM do not seem to be so well embraced in the Southeast Asian construction industry (Cheah & Ting, 2005). In Malaysia, VM was first introduced in 1986 and despite some benefits being observed as a result of its application, VM has not yet become widely practiced in the Malaysia (Jaapar et al., 2007; Jaapar & Torrence, 2006).

According to Jaapar et al. (2009), a knowledge gap exists between the current development and application of VM in the Malaysian construction industry as compared to other developed countries using VM. It is posited that this is largely due to the lack of knowledge and regular practice of VM, and also to a resistance to change by the parties involved during Pacific Association of Quantity Surveyors (PAQS 2010) Conference, Sentosa Island, Singapore VM seminars (Jaapar & Torrence, 2006). A preliminary literature review has indicated (Che'Mat & Shah, 2006; Ghani, 2004;

Jaapar et al., 2008; Jaapar et al., 2007; Tan, 2005; Teck, 2003; Tek, 2004) that some client organisations in Malaysia have been applying certain aspects of the VM methodology and concepts in their project operations, however due to some unsuccessful outcomes, the take up of VM practices in Malaysia has not been large (Jaapar et al., 2009). Despite some resistance to applying VM due to lack of knowledge and stories of past experience by clients, nevertheless, the construction industry professionals acknowledged that VM contributes to the achievement of value for money. Based on a study conducted by Jaapar et al. (2009), there is a positive future for VM within the Malaysian construction industry as professionals from various segments of the industry now appear ready to implement VM applications in their future projects. The level of awareness and appreciation of VM as an essential toolset for providing better value has developed over time since the inception of this study to the extent that the Institute of Value Management Malaysia (IVMM) was established in 2000 with help and encouragement from Government agencies such as the Professional Services and Development Corporation (PSDC). The latter agency has initiated great efforts to promote and provide training courses in VM within the construction industry. This continuous initiative has opened new opportunities for VM to be accepted into companies at a senior management level. The recently issued Government circular "Value Management Guideline Circular 3/2009" authored by the Economic Planning Unit of the Prime Minister's Department mandates that for every construction project valued at more than RM 50 million, a VM study is required to be undertaken (Economic Planning Unit Malaysia 2009), This marks the beginning of a new paradigm for VM in the Malaysian construction industry, which is expected to allow for more potential areas of VM to be developed and introduced into the sector.

2.11 VM application in Malaysian public projects

In Malaysia, Jaapar (2006) stated that the VM in Malaysia is still at the early stage of its evolution as it had only started to be used only in 1986 and were without the support of the Government; hence its application was minimal. Despite its infancy stage of implementation to the construction industry, on December 2009, the authorisation of Value Management Circular 3/2009 by Economic Planning Unit (EPU) has made all public projects exceeding RM50 million to implement the VM studies resulted in massive (2011) stated that 71 projects had applied VM studies which had resulted in 23.53% of monetary savings from the total cost.

By May 2011, in order to ensure standardisation in its implementation process, the EPU published the Manual of Value Management Implementation (VMI) for Government Projects in order to provide a proper guideline for the key players of the construction industry to implement the VM studies. The National Development Planning Committee (NDPC) were also formed to monitor and to ensure the implementation of VM in the government projects. Figure 2.4 shows the organisational structure for VM implementation in public projects. There are three (3) stages in VM application for public projects and each stage are handled by different government agencies. The process of VM application is being divided into three (3) which are the Value Assessment (VA), VE and Value Review (VR).

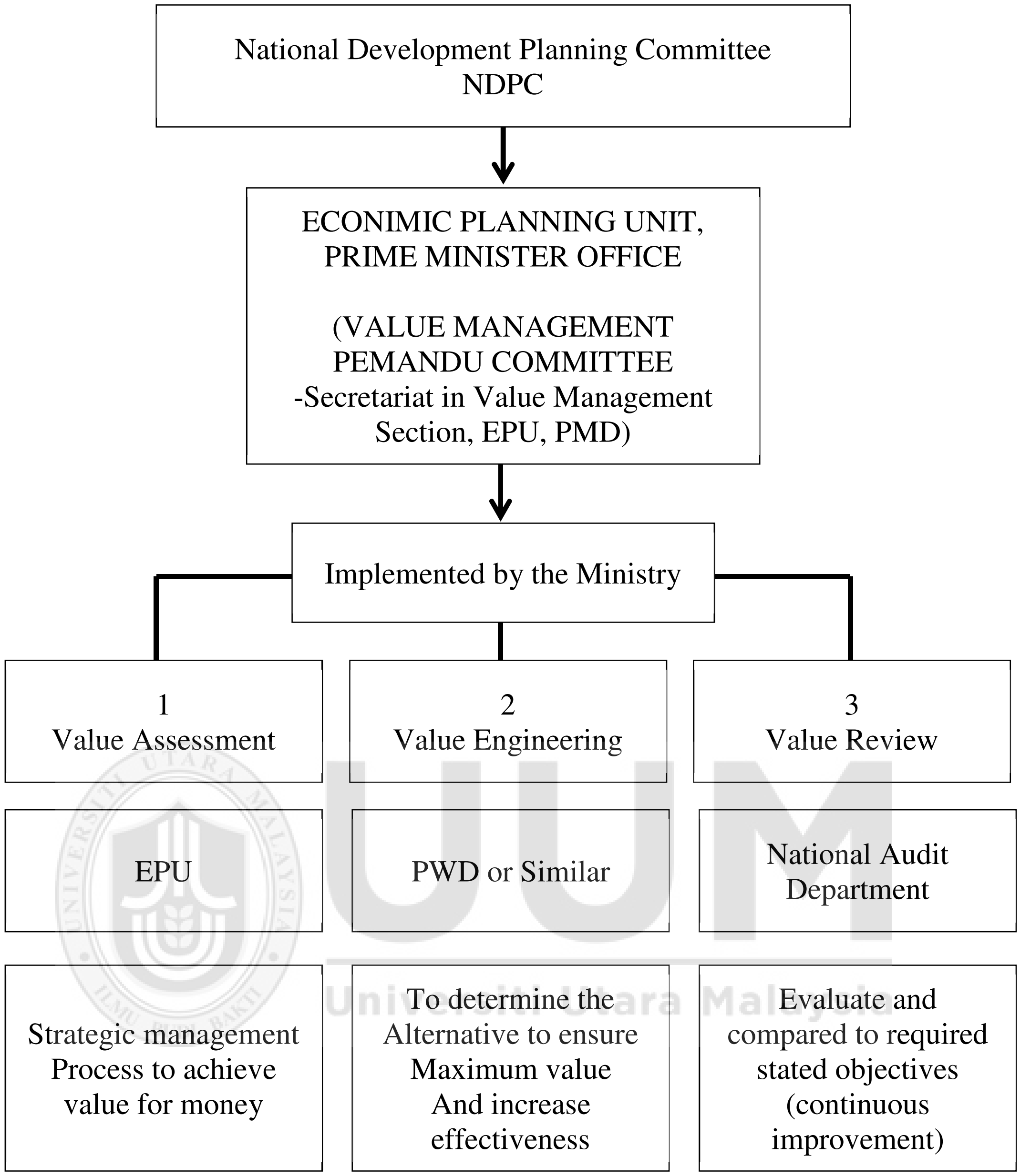

Figure 2.4
Organizational structure for VM implementation; adopted and modified from: VM Manual, EPU (2011)

2.11.1 Value Assessment (VA)

Currently, the manual dictates VA process is carried out as a strategic planning implemented before a project is approved. This process is similar to other definitions of VA such as value planning and value study which has been used extensively in the VM related literatures. The term VA in the manual used to describe the process of planning the government project. The purpose of VA is to identify the projects that can contribute to the achievement of cost optimisation and improve the performance of the projects. At this stage, the VA is used as one of the management strategies to achieve value for money because at this stage the real needs of the project can be verified.

2.11.2 Value Review (VR)

VR in the manual refers to the process of VM implementation after the project is completed, so that the project performance can be evaluated and compared to the required objectives. It is also an effort for continuous improvement to improve the weaknesses and improve effective implementation of the projects on. At this stage, the effectiveness of a project in fulfill its functions will be informed to the relevant ministries and agencies applicable to embedded or enhanced the projects in the future. Weaknesses found will also be informed in order to avoid this from happening.

2.12 Future Growth of Value Management

In the last decade, VM had spread from the traditional emphasis on value for money to adding value to environment, systems, quality, social and ethics which are somewhat if not more important value to the projects or products. Cheah and Ting (2005) found that VE is being practiced in South East Asia, and there is strong belief that bright future for the practice although there are obstacles along the way. Additionally, Mohamad et al. (2010) noted that both public and private institutions have starting to include VM syllabus in their curriculum it is found that undergraduate of any discipline can be trained as VM professionals through on job training. It is found that VM has evolved to wider and higher perspectives of application from “hard” VM to resolve well defined problems to “soft” VM to tackle other complex problems that uses multidisciplinary teams.

Mohamad et al. (2010) also suggested that construction industry should play a big role in promoting VM as part of their service not just through QS perspective which is commonly understood. There is hope for the growth in Malaysia as there are projects which have successfully implemented using VM application and efforts have to be intensified to improve the applications and to add value to the clients (Jaapar et al., 2009). In ensuring the government implements better value-for-money approaches in public projects, the Economic Planning Unit (EPU) and the CIDB in December 2009 have initiated efforts to utilise VE Management processes, through its circular entitled "Value Management Guidelines Circular 3/2009" which made it mandatory for public projects valued at RM 50 million and above to implement VM (Jaapar et al., 2012).

2.13 Value Management Job Plan

The VM job plan from structural engineer point of view as the author has almost 30 years of experience in VM application on structural and geotechnical design. Chung et al. (2009) defined the information phase consists of gathering all related information required to conduct function analysis. VM can be most effectively applied in planning and design stage because the later application during the construction stage will increase the cost greatly (Chung et al., 2009). Although construction project can be planned, the complex factors and risks involved have made the industry rather become unpredictable. Risk factors in satisfying client's requirement have always been ignored in VM study due to client unable to convey their specific requirements and needs objectively (Hamid et al., 2011).

Al-Yami and Price (2005) observed that many value practitioners have written their VM job plan with different phase and order which range in between five to eight phases but the VM job plan techniques are still same in each plan. It is a sequential process conducts systematically by experience and qualified professionals through several phases as follows:

i. Pre-Study
ii. Information phase
iii. Function Analysis phase
iv. Creative phase
v. Evaluation phase
vi. Development phase
vii. Presentation phase
viii. Implementation phase

Getting all major stakeholders to attend VM seminar will bring all team members closer together to achieve mutual understanding of the requirements and limitation of each team members which individual meeting by project leader will takes weeks or months with probably without the same results or consensus (Clifford, 2006). However, solution through VM often not well received due to lack of clear guidelines and measurement quantification, method of evaluation and exaggerates opinions by VE proponents (Chung et al., 2009).

2.14 Summary

Throughout the literature, it can be found that the effective combination of management and design functions in design and construct projects has been highlighted as a key subject in success of construction projects. On the other hand, any failure in coordinating design, management and construction amongst various sections can significant affect the attaining of the client's aims. The influence of such failure could lead to a longer time to complete the project, cost overruns and poor end-quality. Based on a case study accomplished by Panciuk (2009), there is a high risk of the construction cost 'blowing-up' if actions such as contingency recommendation, design coordination and the contractor not being given with entire information, in specific drawings, are not correctly managed during the primary design stage of a construction project.

Moreover, from the literatures, it can be emphasized that the VM has been identified as a factor which is crucial to the success of projects. Most VM presently practiced in the industry emphases on the design improvement and development to the project functions. S. Green (1999) expressed that VM givens a ‘second look’ at design decisions which have been taken in response to a projected cost overspend. It concentrates on value rather than seeks and cost to achieve an optimal balance among quality, cost and time as it offers a technique of integration in the building process which no other management structure in construction can offer (Kelly et al., 2009).

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This chapter establishes the methodology and approach employed to achieve objectives. Action research is used in this study and organization of the current study is described. Three block diagrams or parts of studies have been conducted to complete the research. The first part was through quantitative study where a survey was conducted on VM application amongst clients, consultants and contractors in Malaysian construction industry. Survey questionnaires have been distributed to VM seminar attendees in Kuala Lumpur. The second part of this research explores the details through interviewing selected respondents to obtain more in-depth details on their experience of VM in building construction industry and collecting and analysing their perceptions. In the third part, a framework that could be guideline for VM application in Malaysian construction industry was developed to effectively reduce the project cost.

3.2 Action Research

Action research (AR) is a part of methodology family which pursues action and researches concurrently where some researcher emphases on theory while other are data driven (Dick, 2002). AR has been practiced over 50 years with different explanation and clarification by different researchers (Earl-Slater, 2002). In action research, researchers will experiment the theory with practitioners in real situation, received response from this experience, modify the theory based on the feedback and redo the experiments (Avison et al., 2001). According to Stephen Corey in 1953, action research is a process which practitioners try to study their own practices scientifically in order for them to direct, make amendment and assessing their choices and practices (Earl-Slater, 2002).

AR aims to build up practical approach and skills of the practitioners in the absence of clear targets and goals with emphasis on process criteria and the differences of the research from other method especially in studying social characteristic (Altrichter et al., 2002). In recent decades David Hopkins in 1993, proposed that AR as a casual, qualitative, decisive, prejudiced, interpretative, contemplative, and empirical model of inquiry while Emily Calhoun in 1994 simplified that AR in layman's term such as "let's study what's happening and decide how to make it a better place" (Earl-Slater, 2002).

Action research naturally used to describe the academic supposition of researcher and the research project, thus many researchers have focused their investigation on AR as a concept (Altrichter et al., 2002). AR proved its usefulness and growing acceptance of its scope as one of research methodologies although it does not have a precise and generally accepted definition (Altrichter et al., 2002). Figure 3.1 shows the general pattern of AR process.

"In action research, the emphasis is more on what practitioners do than on what they say they do"(Avison et. al., 1999).

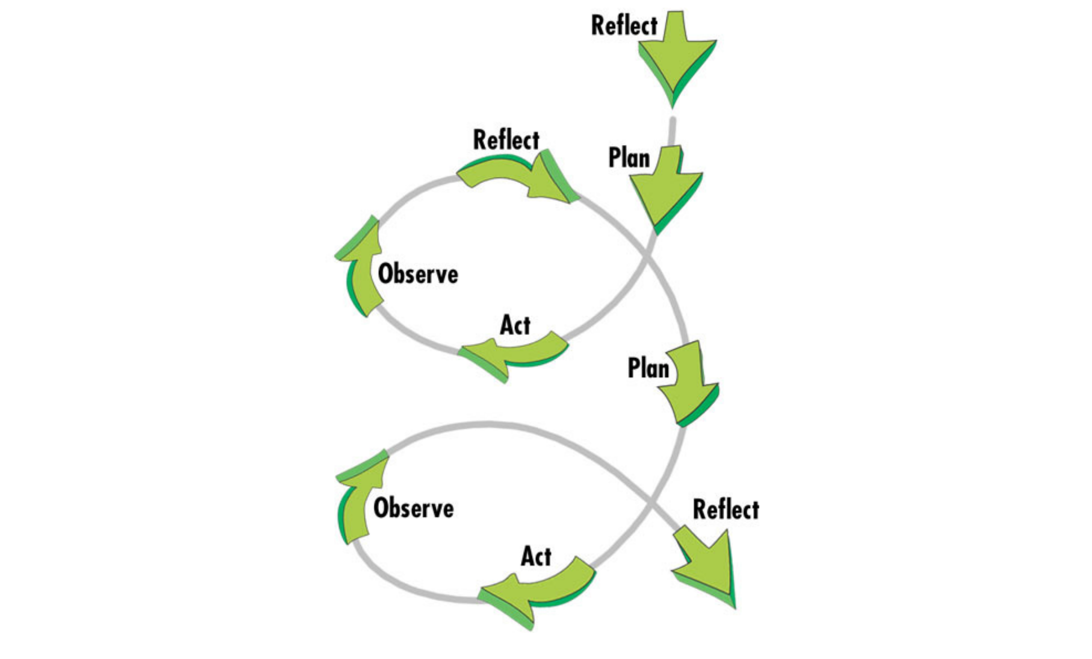

Figure 3.1
Action research process diagram

3.3 Research Strategy

This section studies the contribution of VM into the organization. The focus is to evaluate the efficiency of VM application in design process as well as accomplishment of better cost optimization for construction projects undertaken by respondents. Required data is subjected to the selected approach and objectives this research. Selection of the data collection method is dependent on data types by which the arguments or objectives should be supported, (Naoum, 2003). According to Allison (1993), the following process forms the research methodology:

3.3.1 Review

Literature review is the initial and a systematic part of any research process carried out to comprehend the topic before further proceeding with the research and to inclusively collect all information needed from journal, books, articles, reports, records and previous researches.

3.3.2 Data Gathering

A systematic and structured method of data collection is data gathering for which a set of questions or research points are set up and given to respondent to response accordingly. An effective survey and data collection is structured to standardize and control the intended information gathered from the respondent. It is necessary to ensure that the data is effectively extracted from the survey questionnaire mostly because the survey questionnaire is designed particularly for a purpose. The general scheme of the data gathering framework is depicted in Figure 3.2.

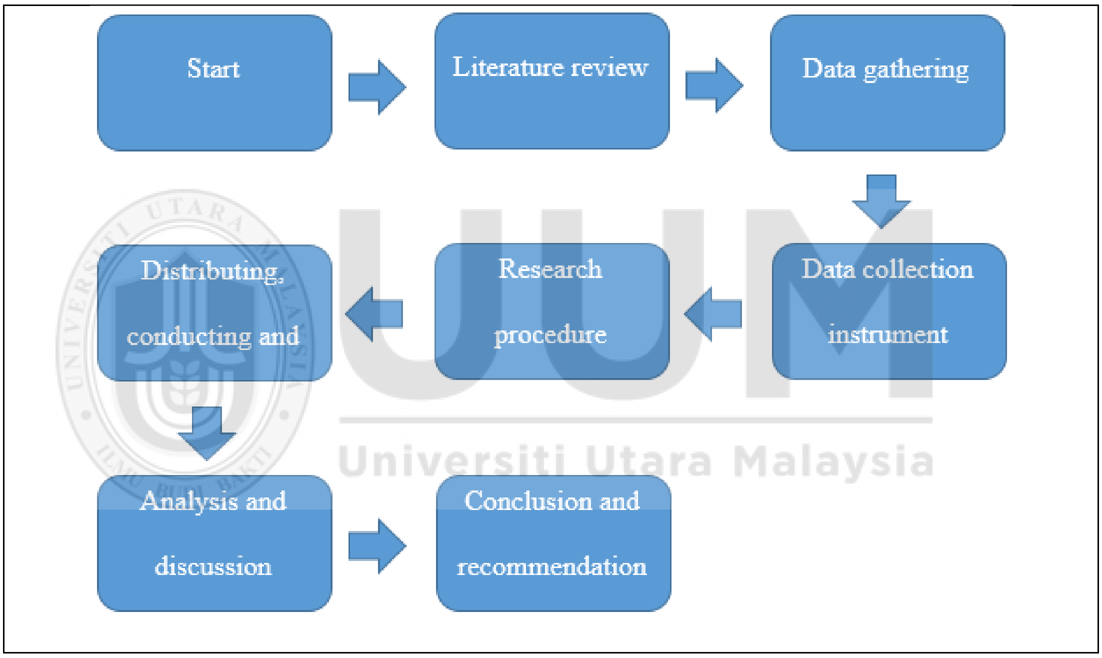

Figure 3.2
Data Gathering Framework

Therefore, the initial step in data collection is to complete the survey questionnaire by respondent. Second step in data collection is conducting on actual projects.

3.3.3 Survey

Initial phase of data collection process of current research is performed among VM seminar participants aiming to establish a comprehensive understanding framework on the practice of VM in building construction projects. VM participants are asked for their information and perceptions. This questionnaire survey is able to capture the opinions and views of a large audience and accumulate a higher response rate within a short period of time.

Questionnaire distribution is regarded as the data source conducted through quantitative approach. The researcher has distributed a number of samples to the respondents in the VM seminar in Kuala Lumpur from diverse level of organization's management in order to fulfill a quantitative research and to quantitatively analyze particular feedback. The designs of the questionnaires are in accordance to the study objectives and literature review.

3.3.3.1 Questionnaire design

The survey questionnaire contains two parts and respondents are required to respond to each item based on a 5-Likert scale response format (1 = Strongly agree to 5 = Strongly disagree). The sections deal with perceptions of the factors that constrain application of VM and suggestions to ensure better execution of VM in the Malaysian construction industry. Part 1 refers to demographic information about respondents such as current profession, highest qualification, year of experience in VM, position within the respondent's organization and characteristics of that organization and current practice of VM. Part 2 consists of six Sections. Section 1 focuses on the nature and extent of VM application on construction projects in Malaysia. The questions in Section 2 investigates the benefits of VM application in construction projects, such as cost reductions; factors influencing the use of VM, such as design innovations; and metrics for measuring effectiveness of VM on construction projects. Section 3 examines the reasons of why VM is not received well in Malaysia; covering factors such as examine the difficulty of VM application, lack of combination between all professions, lack of contractual provisions and conflict of interest between stakeholders. Other sections were established in accordance with respondents' awareness of effectiveness of VM in university syllabus and the suggestions for future implementation of VM. Concentration of majority of the questions is on the respondents' awareness to the objectives. This exposure points out the level of understanding towards the objectives.

3.3.3.2 Quantitative analysis

This section will explain the process of the quantitative analysis used for data collected through the survey which aims to get data frequencies and instate the nature of the relationship between variables and factors associated with the implication of the VM in building construction project. This analysis concentrates on producing descriptive results.

In the considered analyzing data, descriptive statistic method is employed to obtain a research general overview. The distribution frequency is assured by disseminating the collected data into several groups. The mean distribution and occurrence are depicted by graph, pie chart, and bar chart. In accordance with the research objectives, the gathered data was used for descriptive purposes. Descriptive information required for this analysis is provided through a self-report questionnaires specifically designed for this purpose and statistical analyses are performed by Statistical Package for the Social Sciences (SPSS, version 23) to study and analyze the VE practitioners' survey feedback. All descriptive analyses are carried out with data based on standard deviation, mean, percentage and frequency.

3.3.4 Interview

In order to explore the concept of the VM application in design development an interview approach was considered with the aim of investigating participant's specific and individual experience in VM and deeper exploration of the experiences of VM participants in specifically managing the design development of a construction project. In a single or continuous forum there are creative inputs of many stakeholders in design development to enhance the value of the original design. In order to measure and tap the real value of participant's experiences and perceptions in VM, a different approach is required for extended exploration and deeper understanding. It is meant to literally attempt to shed new light on old problems in VM (Rubin & Rubin, 2011).

According to McNamara (1999) and Champion (2006), particular outcome of interviews is obtaining the story behind participant's experiences as well as a supplement to questionnaire administration. So, an in-depth investigation around the topic needs further clarification of responses. An interviewing process can effectively explore social processes since interviewees give oral elaborations of answers which could be determined just by reading the questionnaire response. During interviews researchers reconstruct events of the VM application (Rubin & Rubin, 2011). Through this valuable data gathering tool it becomes viable to explain the social setting and people within such settings Champion (2006).

3.3.4.1 Selection of interview method

Yin (2013) has defined three types of interview methods namely structured, unstructured and focused interviews. The first type, structures interviews, is more rigid in their composition and line of enquiry because of specific predetermined fixed questions. The researcher's full focus is on the list of questions and asks the same questions to different respondents and as Champion (2006) mentions, a high degree of interview control is reflected and questions are only limited to the relevant factors of the problem being investigated. Unstructured interviews, as the name explains, are in contrast with former type and less rigid in their line of enquiry and often are seen similar to natural conversation. The characteristic nature of the unstructured type of interview is in its direction and intensity which are determined by situational factors.

Merton, Fiske & Kendall (1956) discussed the nature and rigor of the conduct of the focused interview and believed that focused interviews actually form part of the structured interview method. This is also supported by Champion (2006) who asserts that focused interviews are built upon how much is known about the target population in advance and by this the direction of the investigation is dictated. A quote from Champion (2006, p. 254), describes that focused interviews are "interviews with respondents who have shared some common experience that has, in turn, been carefully scrutinized by investigators to generate hypotheses about the effects of the experience as viewed by the participants". The focus point is the respondent's experience towards particular subject of the study.

The major aspect of this research, with VM as the object of the study, is investigating the shared common experience of seminar participants. In addition, identification of differences in the participants' experiences regarding application of VM in design development is hoped to be carried out to obtain a sound base for a new framework. Hence, this research study conducts interviews with VM participants.

3.3.4.2 Vignette to interview questions

Barter and Renold (1999) and Bryman (2015) highlighted avoidance of assisting interviewees by general questions at the beginning of the interview. Instead of helping interviewees to understand the context of the enquiry they rather suggested utilization of vignette questions as a small clarification of the case for interviewees to be able to see and account for behavior in particular situations.

According to vignette approach, an overview of the research topic is provided for interviewee. By giving a short introduction at the beginning of the interview, vignette approach presents a broad overview for interviewee such that he/she can structure his/her responses to questions. The following is the vignette statement cited at the beginning of each interview of this research:

"*Value management application in construction project has proven to assist construction team in making structured approach to decision making in the design of a project. The involvement of multi-disciplinary team participant in VM seminar allows for comprehensive review of the design with aim to improve construction process on-site. However, their degrees of involvement in the seminar process are influenced by the level of skills, knowledge, experience and other related factors. The aim of this interview is to explore these issues and finding practical solution to improve current design practice and hence construction process on-site.*"

3.3.4.3 Main interview questions

Interview questions are prepared to explore the application and organization of VM practice in with a much deeper extent. The assistance for giving general overview to interviewee regarding the purpose and the key result of the survey was provided with a vignette statement at the beginning of the interview. There are 10 main interview questions considered and designed to investigate interviewee's opinions and perception about the topics. These questions are as follows:

(1) What is your purpose of attending in VM seminar?

(2) In reviewing the design for the present project, what is your perception on VM influence in improving construction process on-site?

(3) In your opinion, do you think that VM focusing on design will assist in improving construction process on-site?

(4) In what aspect does VM study can improve the design of the present projects?

(5) How does multi-disciplinary involvement in VM seminar influence design outcome of construction projects?

(6) Do you observe any limitation of multi-disciplinary participants in seminar in term of their contribution?

(7) What are the main attributes of a participant that make an effective VM seminar in reviewing the design of construction project?

(8) How do you view participant's level of knowledge/skills and experience in this seminar?

(9) What are your suggestions to improve these attributes among future participants?

(10) Considering maximizing the outcome of the VM study for construction project, what can be done in increasing contributions by participants looking into the design?

3.3.4.3.1 Measures to eliminate bias during interview process

Rubin and Rubin (2011) discussed that researchers normally have a strong feeling about their topics and sometimes they feel risky to share their thoughts with interviewees. ibid (2005) further cautioned that researchers should refuse to express their own views during the interview. Sharing views with interviewee results in having a preconception about the topics at the beginning of the interview and it may indirectly influence the interview process. Hence, the researcher should know and acknowledge the potential and real biases exist in interview process that may impact the direction of the conversation.

3.3.4.4 Method of interview analysis

Apple iPad™ device was used as the voice recorder as each interview was recorded and saved in a universal format MPEG-4 Audio file format which was later subjected to transcribing process and analysis using NVivo Version 9 qualitative data analysis software. Interview audio files were all transcribed into text format through a multi-stage process which is described in the following subsections. It is noteworthy that respondents' body language may indirectly reveal a sense of what they feel during the interview and this would be not available to external transcribers.

3.3.4.4.1 Software for transcribing

In order to conduct the transcribing process in this research, the F4 application which is available free of charge at http://www.audiotranskription.de/english/f4.htm was utilized. This software has efficient features that facilitate transcribers' adjustment to the transcription process and provide playing audio files as well as transcribing and adjusting the playback speed at the same time. The final transcripts produced by this application are accurate.

3.3.4.4.2 Qualitative Analysis

Analysis of interviews was carried out by qualitative analysis and content analysis was employed to explore the practice of VM application in design development. This analysis is supposed to validate the practice and exploring issues encountered by VM participants in applying VM into design.

(i) Content Analysis

Content analysis encompasses identifying, coding and categorizing the primary pattern in the data (Patton, 1990). Analysis of interview transcript, or raw data, with separate identity provides understanding of the context of the data collected and results in generation of the themes which will help researcher in exploring the context behind each conversation as well as the deeper meaning of the interview data collected.

The approach adopted in this research was introduced by Glaser (1965) known as "constant comparative analysis (CCA) method". This approach is associated with the process of separating themes via reading of the interview transcript (raw data) to generate themes in a few stages until more understanding is developed regarding the topic undertaken by researcher. Each interview transcript is read several times and new themes are generated for each reading. These themes will be compared for consistency. This approach is expected to establish links between findings of research questions and then to answer the research problems with these links.

(ii) Interview transcripts analysis

Computer Assisted Qualitative Data Analysis Software (CAQDAS) was adopted for the analysis to organize, manage and analyze the data Bryman (2015). This software assists this research to organize data in a more structured and systematic way. Application of CAQDAS and method of qualitative analysis employed in this research is explained in the following.

(a) Constant Comparative Analysis

This analysis approach was first introduced by Glaser (1965) to analyze qualitative data and was then improvised by Lincoln and Guba (1985). The constant comparative analysis compares single data with other pieces of data with a similar nature and aims at identification of any existing similarity or differences between data throughout the comparison process. The interview information is first analyzed and pieces of information are sorted again into emerged themes eventuated from the analysis. According to Grove (1988) and Thomas (2006), this naturally inductive analysis process facilitates understanding of the data in a much greater context through constant development of data categories.

(b) Analysis using NVIVO

NVivo Version 9 was employed to help researcher in organizing and categorizing all collected data through coding for easy retrieval and interpretation. This software allows managing of data with diversity and recording decisions and creating new records (Cavana et al., 2001). However, Sprokkereef et al. (1995) discussed that

CAQDAS cannot assist in making decisions about the coding of textual materials nor interpretation of findings. That is why CAQDAS is adopted for managing qualitative data for easy interpretation while theory development is postponed to a later stage of the research.

(c) Coding

Theme coding system is capable of reorganizing data in accordance with the conceptual theme based on the researcher's initial setup (Minichiello et al., 1990). As discussed by Bryman (2015), coding includes reviewing transcripts and /or field notes and assigning labels to component parts which seem to be of potential theoretical significance. Process of coding entails transferring interview transcripts into themes which are generated according to the researchers' interpretation of the data.

(d) Methods of Coding

Strauss and Corbin (1990) and Bryman (2015) have identified three types of coding method; coding method that are open coding, axial coding and selective coding. Based on the steps suggested by Charmaz and Belgrave (2002), the current research applies open and selective approaches for interview transcripts - the general coding at the beginning of the analysis process (initial coding) which is then followed by much more specific coding (selective coding) as the process goes on.

The open coding approach initially applied in this research allows exploration of the interview transcripts with an open mind to identify any potential concepts that are specifically in relation with further exploring the VM. The open coding process is carefully and comprehensively carried out through reviewing the transcription and giving codes based on the researchers' understanding of the data. After identifying the core categories as the central focus of this research the selective coding was followed to assist with further breakdown of coding. The later is performed through giving codes to the selected texts from the transcriptions which are specifically in relation with core categories.

3.4 Research Strategy of actual projects

VM consultant needs to plan the design and this requires more than a single design to compare the cost. In addition to that, VM consultants have to plan how much budget they need to conduct the VM design, how long it will take to conduct the VM study and where the location of the study should be, i.e. office or fieldwork. Furthermore, VM consultants play an important role in training good staff such as engineers, quantity surveyor and project manager to carry out VE design, calculation and management. VE training and job training are usually essential for all engineers even for experienced ones prior to VE design. These trainings may begin from simple designs like terrace houses, bungalow and then move on to high rise buildings. Latest engineering software packages are used as they do better modelling and engineering optimisation.

VM team members are selected based on the expertise and they all should contribute in information gathering process. Prior to the VM study set off, the team leader conducts a meeting about the new project and provides a work programme or plan to clarify how to reach the target. A list of requirements is also proposed after the meeting.

3.4.1 Information Phase

The information phase consists of gathering as much related information required as possible. All information will be obtained from clients including the existing design, scope of works and budget and completion date (Chung et al., 2009).

For Structural evaluation purposes, the following data is required for VE studies:

i. Architect, civil and structural, Mechanical and Electrical drawings
ii. Soil Investigation reports
iii. Other related reports

3.4.2 Function Analysis phase

Function Analysis is the heart of VM process, and can be described as recognising the function of certain things, or how they function to accomplish the project purposes. Based on the function analysis, wastage, repetition and excessive spending which give the chance of value can be enhanced and explored. This analysis allows the researcher to test the assumption estimated (Shah & Bina, 2006). In this phase VM participants will proceed to study building elements. VM team members who have been chosen before will select a main person who will lead this job and normally this person is an engineer.

Shah and Bina (2006) explained the Job Plan for VM participants and described it in the Technical FAST diagram as indicated in Figure 3.3. In an earlier research work, Borza (2011) described the FAST diagram (Function Analysis System Technique) as a function-based approach analysis of products and processes using graphical representation and logical structure to the function analysis step of Value Methodology.

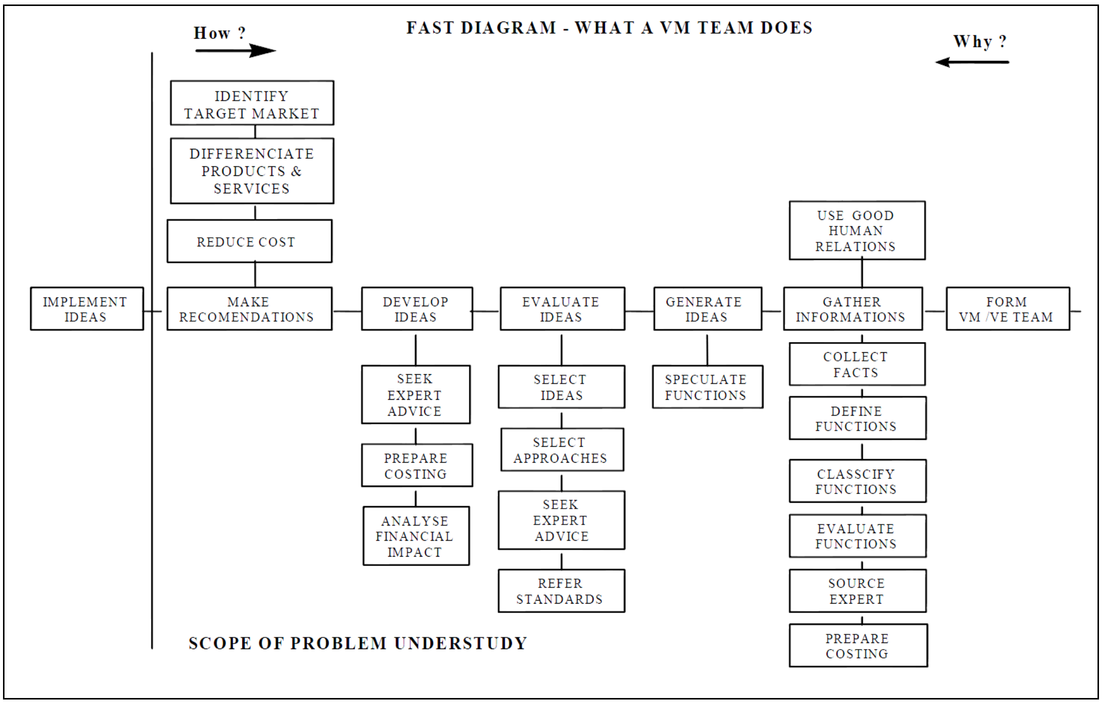

Figure 3.3
FAST diagram – What a VM Team Does

The speculative or creative phase is the process of identifying potential application which can increase the value of the function. In the evaluation or analytical phase, the proposals are analysed and scrutinized to determine the possible option. The viable proposals are then chosen to be developed in other process such as the development and recommendation phase where the best proposal is selected. In the final phase, the most excellent option is proposed to the client for final approval before it is applied into the project (Chung et al., 2009).

When all the information is gathered, VM team will conduct function analysis study. The required drawings and documentations are collected and sorted based on the scope of works. Bench mark is taken from original consultant's drawing and from BQ. Team members will identify clients' needs, find problems and evaluate collected data, brainstorming and discussion. Several proposals will be tabled for VE discussion. It will be based on client's vision, requirement and needs.

3.4.3 Speculation/ Creative phase

Speculation or creative process requires VM team members to find alternative to the proposed solution for the problems. Engineer needs some creative input on how to optimise building weight and reduce elements sizes. Figure 3.4 presents cost reduction through VM process in structural building construction.

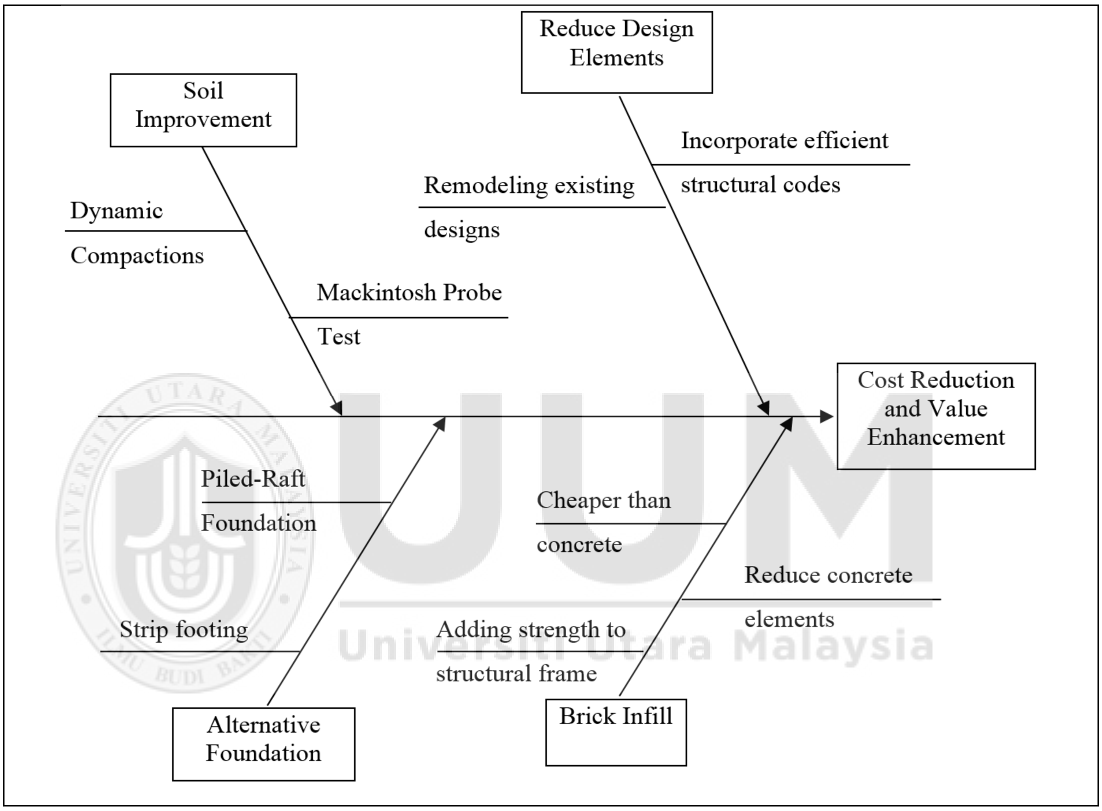

Figure 3.4
Building cost reduction through VM Application (ZNA's process)

3.4.4 Evaluation phase

Evaluation phase consists of several procedures to assess the design. Completed VM designs will go through evaluation process where all designs will be tabled and compared (Table 3.1). These comparisons will go through 2 parts;

- Technical

- Technical part consists of evaluating structural design. All designs will be compared by their constructability, design feasibility, analysis and software used.

- Financial
    - The next comparison is through financial aspect. Only the most optimum design with effective cost will be chosen for the next stages.

Table 3.1
Evaluation Table

Criteria		Design	Cost	Constructability	Remarks
Foundation	Pad/ Pile				
	Strip/ Pile				
	Raft				
	Piled Raft				
Super Structure	Rigid Frame				
	Shear wall/ Load Bearing				
	Total				

1=Good, 2=Satisfactory, 3=Poor

3.4.5 Development phase

Final products of VM designs will be developed in this phase. VM team members will review original designs thoroughly. Quantitative analysis will be carefully scrutinised. Financial proof from costing will determine the final saving. Historical comparison shows that more cost saving can be achieved from the VM designs.

3.4.6 Presentation phase

Completed VE Design will be presented to client, contractors and consultants of VM designs through discussion, presentation, drawing submission. Designs have to be fast in terms of constructability and should comply with local codes which are the BS and Eurocode in this case.

3.4.7 Implementation phase

Project is successfully presented and approved by client and will be constructed based on the VM construction drawings. Problems encountered during and after construction have to be observed all the time.

3.4.8 Cycle 1: Value Management Design – Design for initial costing

- Initial design for costing – A VM team will be assembled and consists of Engineers, Quantity Surveyor and Project Manager.
- Resources required include time, money, and materials. This includes the cost for printing, gathering data and to conduct survey
- Engineers design typical floor that will be used for qualitative studies. These studies comprise comparisons of elements exist in the original design and VE design.
- Comparison from this exercise will be used for preliminary cost savings. If the VE consultant is already appointed, this will be used as the basis for consultancy payment purposes.
- By obtaining new perspectives in the original focused area, the problem statement may change.

Figure 3.5 depicts the whole scheme of the VM process.

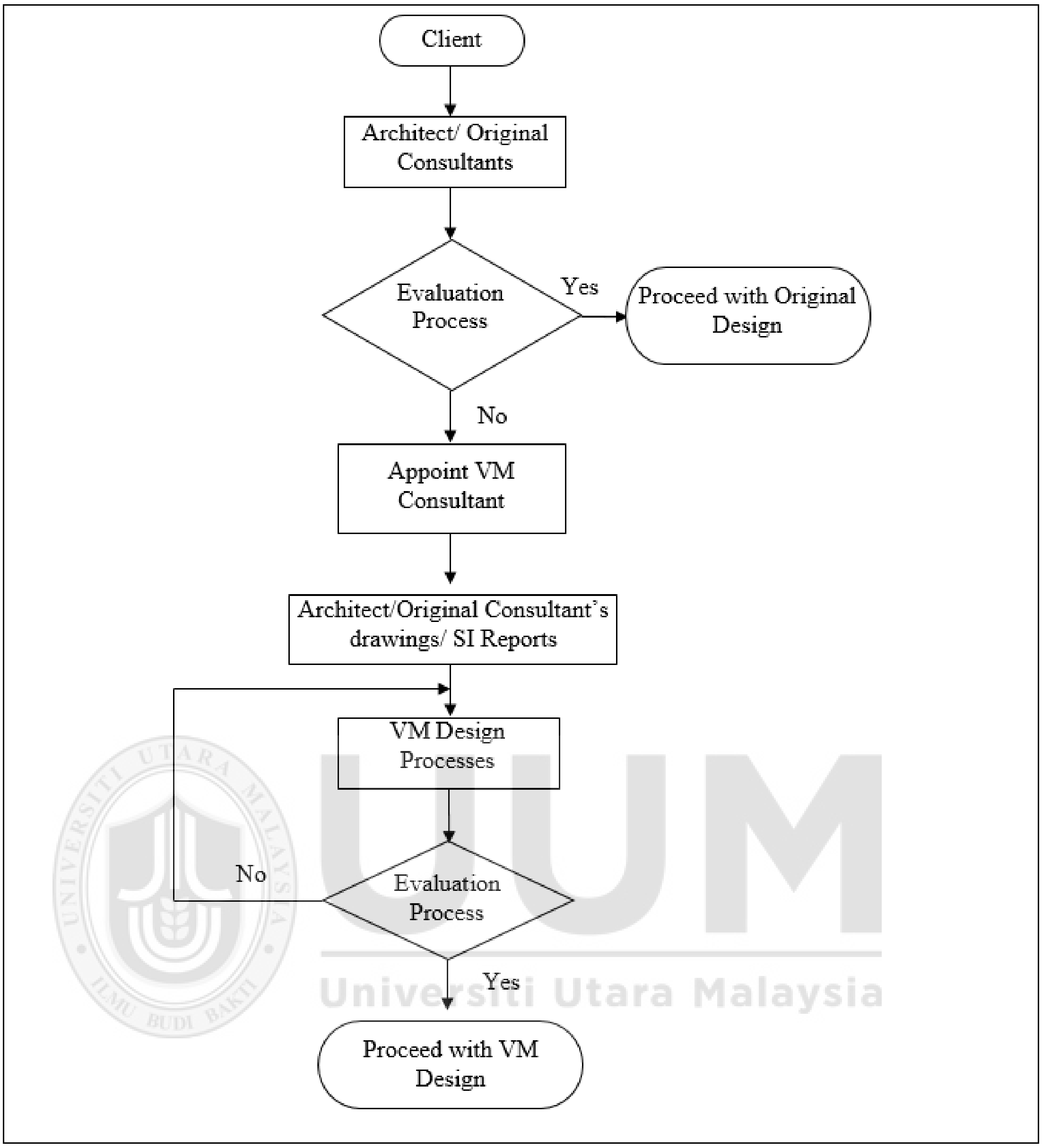

Figure 3.5
Flowchart of Value Management Process (ZNA's process)

(a) Reflect

- Engineers essential to study the architectural drawings.
- Engineers should check original consultant's drawing. This is to see if there is any special requirement for the structure and to check if there is any discrepancy.

- Before carrying out the foundation design, the engineers have to check on the soil investigation report. This report is normally prepared by the geotechnical specialist or qualified civil engineer.
- QS will study any special consideration or clause to be added

(b) Action Plan

- From the typical floor, engineer calculates the building load. Engineer will propose foundation concept.
- QS performs the comparison between VE design and original design to estimate the cost.
- VM Team members will analyse the design and structural aspects of the building. They identify what element can be omitted or changed.
- What other construction methods can be applied?
- Engineers will propose several proposals and will discussed that with other VM team members.

(c) Act

- Engineer will perform the actual design for superstructures as shown in Figure 3.6.

<u>Superstructure</u>

1. Shear wall – concrete or bricks. Vertical wall supporting load, can be constructed in tall buildings.
2. Frame building – Rigid members connected together to make a solid structure. Consists of columns, beams etc. for medium to high rise buildings.

Foundation

Engineer will calculate the estimated building load for foundation design. Structural members distribute load to each member downward to the foundation. Figure 3.7 depicts the VM flowchart for foundation design.

1. Raft foundation
2. Pile Raft
3. Use existing design but will reduce some piles.

- After completing the design, engineer will pass to QS for cost saving calculation. QS will compare the VE design and original design.
- Project Manager will communicate with client and issue out the concept design to client together with the cost savings. Normally client will know roughly the saving that can be achieved using the VE design. In this study, client will reach cost saving from 25% to 35% of the structural cost.

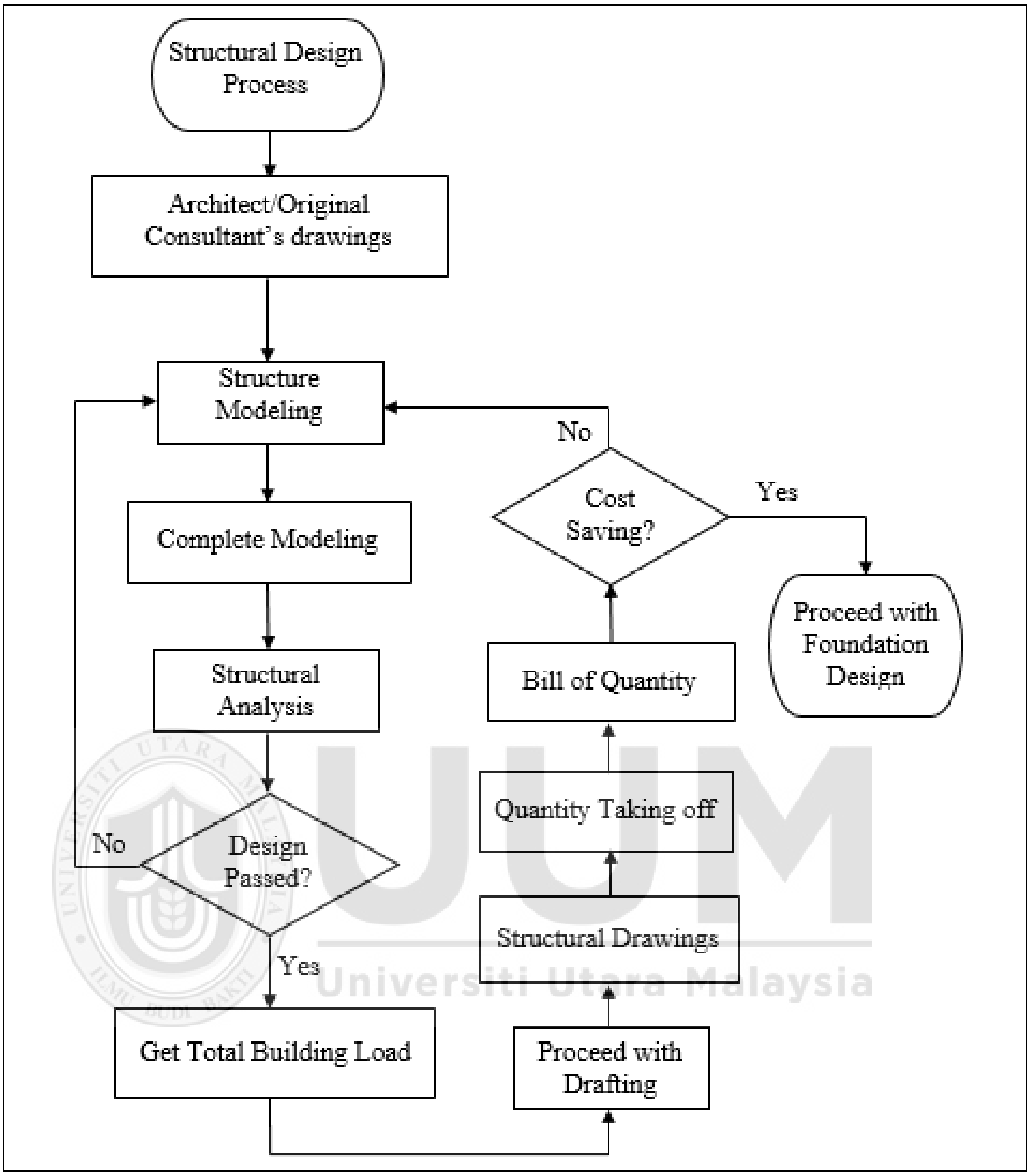

Figure 3.6
VM Process for Structural Design (ZNA's process)

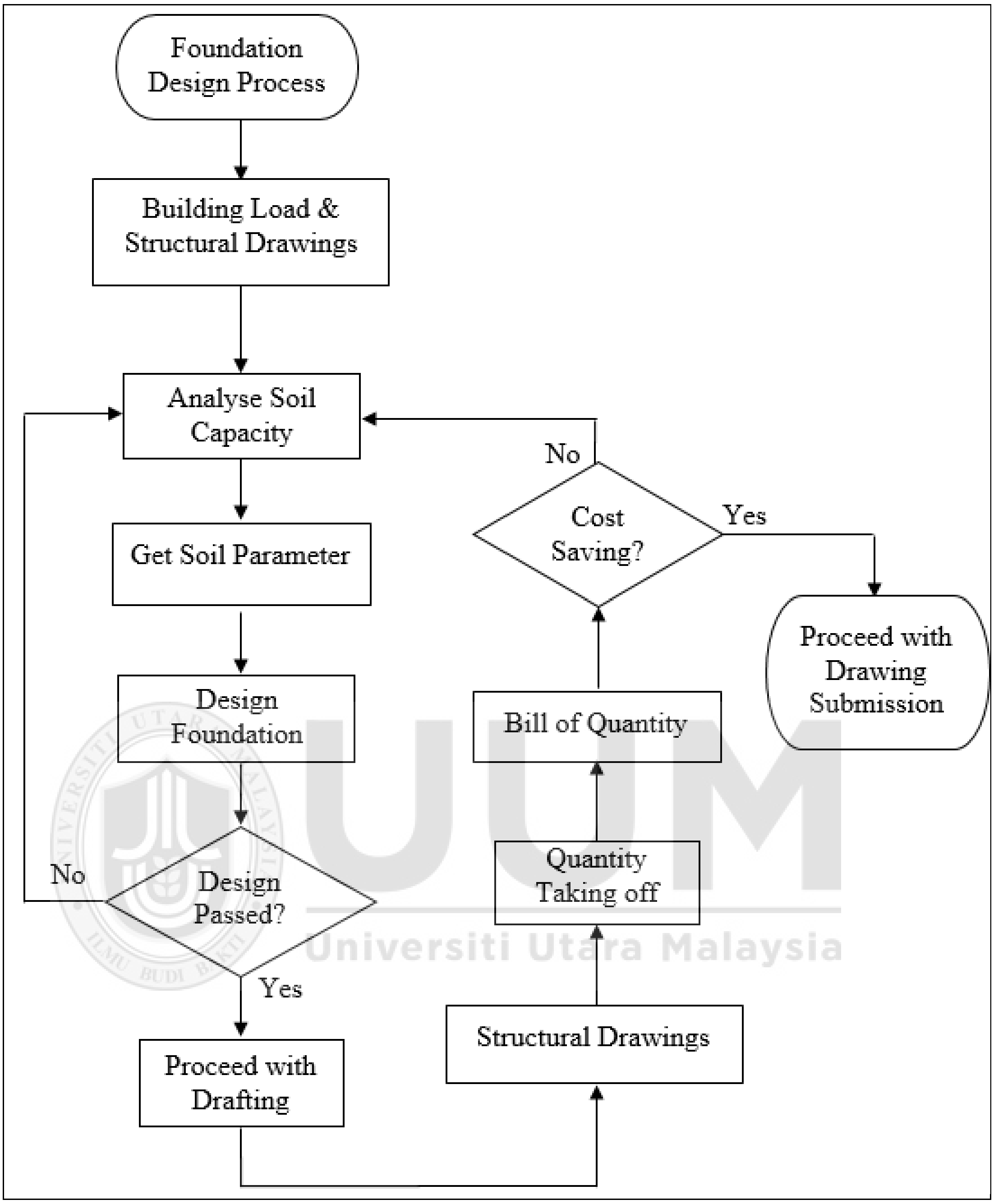

Figure 3.7
VM Process for Foundation Design (ZNA's process)

(d) Observe

- Project manager will communicate with client to get feedback from client. Any feedback from client will be used for the improvement.
- Engineer will check the concept design to see if the design is feasible in terms of constructability or costing.
- QS will compare the cost savings.

3.4.9 Cycle 2: Design for Costing/ Tender

- This is the stage where the actual design with proper calculation will be produced. Drafting to be done for proper tender drawing.
- Costing to be calculated by the QS.

(a) Reflect

- Engineer will reflect on the initial design. To check on both the foundation and structural design.
- Check on the initial cost saving.
- Check on design viability, any problem or discrepancies in initial drawing will be addressed.
- VM team members will conduct discussions or meetings.

(b) Action Plan

- To design the actual building.
- To produce proper drawing for costing and tendering purposes.
- To do proper taking-off for costing.
- To do comparison between VE design and original design.

(c) Act

- Design a complete and actual building that is suitable for tender and even construction purposes.
- Produce proper drawing for costing and tendering purposes.
- Can be considered almost the final design.

(d) Observe

- Check for discrepancies.
- Check on the costing.
- Look for the improvement.

3.4.10 The relation and structure of the VM process and outcome

the VM study was conducted based on the overall investigation process and combined with the characteristics of the project. The work steps which apply VM at the design stage of construction project can be created as indicated in Figure 3.8. The recommended ideas were implemented during the finalization of the designs. A detailed brief was provided on VM together with details of the submission of the project.

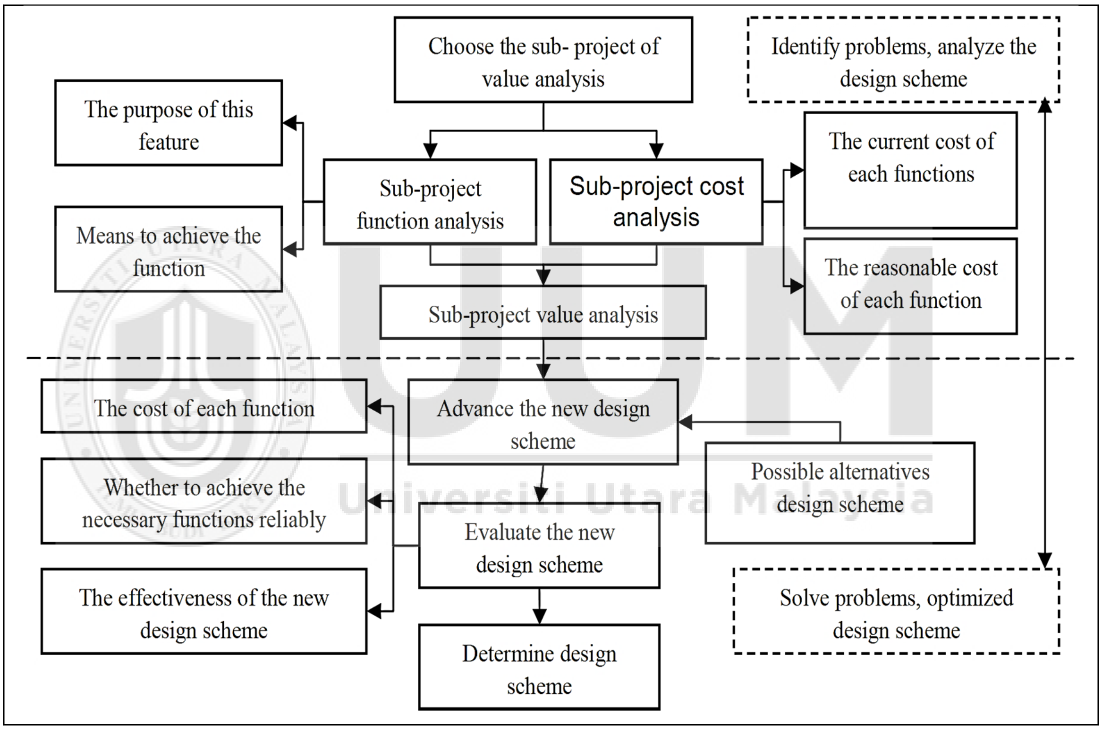

Figure 3.8
The work steps which apply VM at the design stage

In this study, among the present techniques for complex optimization problems the GAs technique has been proposed as a promising intelligent search approach. The following discusses the GAs.

3.4.10.1 The genetic algorithm method

GAs are stochastic search algorithms are built upon the mechanics of natural selection and natural genetics created to efficiently search large, non-linear, discrete and poorly understood search spaces, where expert knowledge is rare or it is difficult to model and where traditional optimization techniques fail, (He et al., 2001b). In GA, a population of chromosomes is generated by randomly creating a set of candidate solutions. These solutions are then encoded into binary strings. Each chromosome in the population is then subjected to an evaluation where a fitness value is assigned to each chromosome based on how well the stated objective is satisfied. Generally, a simple GA consists of three operations: (i) selection, (ii) crossover, and (iii) mutation. Some basic concepts and operators of a GA are introduced in the following before the description of the suggested algorithm is presented.

(i) Selection

In order to reproduce the future populations, chromosomes are selected according to their fitness. In case only the most highly fit chromosomes are involved in the selection, due to the lack of diversity, a very limited solution-space may be achieved although the quality of a chromosome is measured by its fitness value. This is why the selection is a key step within GA solution. On the other hand, increase of the future generations' fitness is not guaranteed by arbitrary selection of chromosomes.

Several selection procedures have been applied in GA programs such as roulette wheel, ranking, tournament, and etc. Roulette wheel selection depends on the ratio of fitness value of a string to the average fitness value of the population. Selection of strings is dependent on their contribution to the mean value of the population, such that those strings which have more contribution are selected for reproduction. Furthermore, strings are linearly ranked in ranking selection according to their fitness and high-ranked strings are chosen for reproduction. In another procedure, namely tournament selection, the strings are usually grouped into pairs of strings in a random manner and the fittest of all groups are selected for mating with each other.

(ii) Crossover

Crossover is the most significant operator in a GA. This operator carries out the mating between two or more parents that are chosen through the selection operator in the previous step. In order to generate new pairs of strings (offspring) with an improved performance index, crossover exchanges pieces of information (bits) among promising pairs of string (parents). Fitter children are created by stronger parents. These parent strings exchange portions of their strings at one or n randomly selected bit positions. Among the crossover operators family, single-point crossover, two-point crossover, uniform crossover and arithmetical crossover are the common ones. Due to the lack of diversity in population of strings, selection and crossover suffer from probable loss of some effective genetic information in the strings and sometimes may even converge to a local optimum. To avoid this and to ensure sufficient variety, the third operator known as mutation is required.

(iii) Mutation

Mutation is a variation in a randomly selected bit of a string; in binary coding this means changing a 0 to 1 and conversely. So, a small probability of mutation should be applied in order to avoid excessive randomness in the search space. This is typically carried out in the range 0.001 and 0.01, while higher values can also be taken, in some cases, to increase the variety of the population. However, the closer the selected probability of crossover to 1, the higher the exchange of effective information is ensured. Combination of the earlier mentioned operators; selection, crossover, and mutation, originates the global nature of search as opposed to when each operator is used individually.

3.4.10.2 Structural element optimization

In this section, the GA optimization method is applied for optimal estimation of structural element through defining a database.

For this purpose, a binary GA with tournament selection is utilized for picking individuals and subjecting them to crossover and mutation. The two-point crossover is used for every chromosome of the chromosome-pair with a 50% probability of selection; the two parents selected for crossover are responsible for exchanging information which lies between two randomly generated points within the binary string. The chromosomes are the representations of tentative solutions, which can be evaluated by a fitness function. The fitness of the chromosome is determined by the fitness function. These chromosomes are then subjected to genetic operations to generate next-generation chromosomes. This occurs repeatedly until discovering the chromosomes of acceptable solutions.

The selected chromosome is associated with three kinds of variables: the element locations, element size and reinforcement bar. The GAs use bit strings to represent their chromosomes. Consequently, each gene of the chromosome may be either 0 or 1. Therefore, bit strings may be directly utilized for encoding the candidate solution.

In order to formulate the structural element optimization problem obtained by ETABS software, the following fitness function is applied:

$$\max Fit = \|1 - \rho^n\|_2 \tag{3.1}$$

Where$\|.\|_2$ is the Euclidean norm, ρ^n is the ration of steel bar to structural element dimensions at specified location n. To sum up, GA is used to optimally search for structural elements. Figure 3.9 presents the whole scheme of the optimization algorithm of structural elements.

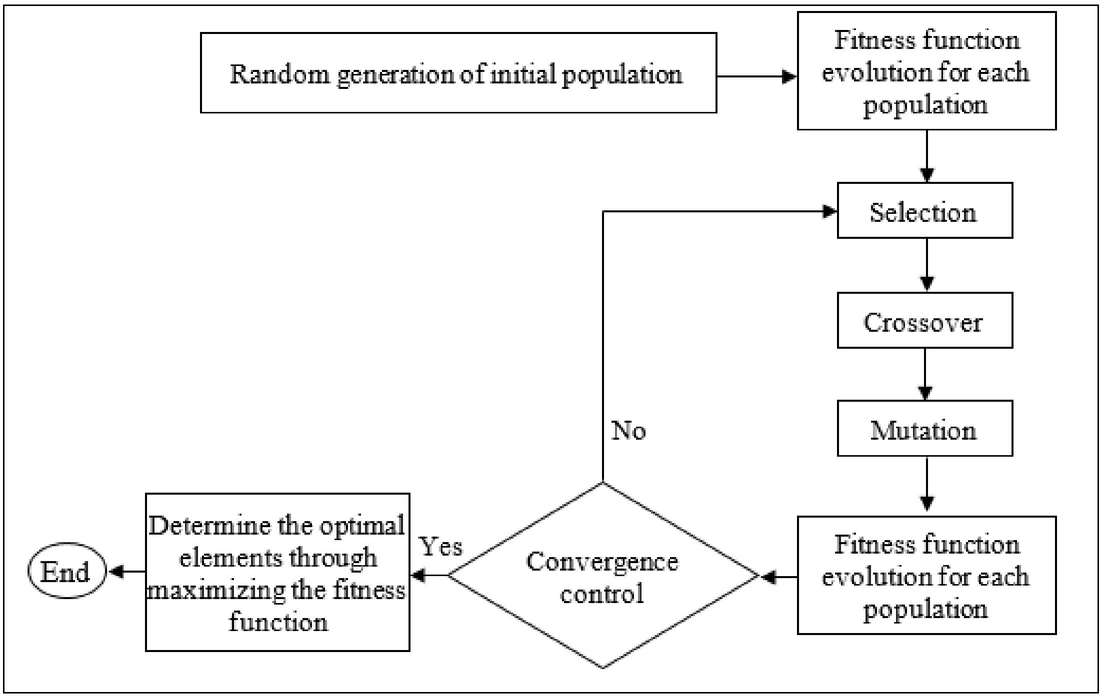

Figure 3.9
Flowchart of the proposed optimization algorithm

3.4.11 Cycle 3: Design for Construction

- Final design – Ready for construction
- To be used for site works
- To ensure drawings can be used for site works
- Contractor already appointed, any major changes will affect the project cost

(a) Reflect

- Find the discrepancies in Tender drawings
- Practicality of design
- Find how to add value to the design

(b) Action Plan

- To plan for construction drawing so that it can be produced before construction commences.
- To amend any discrepancies

(c) Act

- Check and design for the final submission. Minimise errors,
- Produce construction drawings and design calculation

(d) Observe

- Observe on how design can be improved in future projects
- Check on the queries and request for information (RFI) from the site people
- Check on the cost saving from the VE design

3.4.12 Conclusion

In conclusion, AR methodology consists of the following steps;

Reflect – Think about what we want to focus on

Plan – Plan what to do

Act – Carry out plan, collect evidence

Observe – Observe, monitor and record

Reflect – Reflect on what has happened to improve further.

3.4.13 Site investigation

3.4.13.1 Soil Investigation Report

In structural foundation design, SI report consists of a set of report of the soil investigation work performed by the geotechnical engineer or a qualified civil engineer. SI report will be conducted before foundation design being carried out and normally will be financed by the client /developer.

This report is the main sources of information for engineer to understand the ground beneath the proposed buildings. Information such as the water table, fill or cut ground, or low strength soils will be indicated in the report.

3.4.13.2 Site reconnaissance

Site reconnaissance and inspection will be conducted to assess the real conditions of the sites. Obstructions to the design and construction will be notified.

3.4.13.3 Desk study

All building constructions start with architectural design through extensive study conducted by clients and local authority. The architect will then produce design that satisfies clients' needs and requirements. Architect will then issue the overall design concept plan for the project to other consultants. After receiving the architectural drawings, engineer will study the design of structural elements. Original design is used to find where the unnecessary design is or which elements are overdesigned and to propose VM design that is safe and cost saving. This VM design is used to determine the amount of cost saving that can be achieved through the VM process.

3.4.13.4 Bill of Quantity

Bill of Quantity (BQ) from the clients will add some information to quantify the cost of the building. This allows the engineer to compare the cost of VM design to the original design.

3.5 Summary

This chapter presented a VM procedure in order to control the cost in construction projects. The core of VM is function analysis which seeks for achieving necessary functions of products reliable at the lowest cost, and to pursuit the match of product features and costs.

The context developed from this research consists of three parts; firstly, the quantitative analysis of the survey was conducted using descriptive statistical analysis techniques. Secondly, to explore further in-depth details of the VM participant's experiences, subsequent interviews were conducted. A constant comparative analysis method was used to analyse qualitative data (i.e., interviews). Thirdly, a framework was developed to effectively reduce the project cost by optimizing the structural elements. The GA was applied to optimize the algorithm so as to determine the best structural elements by means of the fitness function to control investment of construction project at design stage.

CHAPTER FOUR

ANALYSIS

4.1 Introduction

The construction sector of Malaysia has been very well contributing to the development and economy of the country and it has been chosen as the research location in terms of research knowledge of the sector and geographical factor. In 2013, the CIDB of Malaysia reported that within time period of 2009 to 2011, the construction sector had average contribution of 3.3% to the Malaysian GDP. According to CIDB, the construction sector is categorized into four divisions - infrastructure, non-residential, residential and commercial. Based on the CIDB's report in 2013, the biggest contribution (68% of the total value of work) among all divisions in 2011 was carried out by infrastructure category. This rooted in significant contribution of both private and public sectors as well as Foreign Direct Investment (FDI) and Domestic Direct Investment (DDI) projects all focused on the 68% contribution of the Construction industry to national GDP.

Compared other developed countries such as United States, Hong Kong, Australia, and Japan who are ahead and have already established VM, application of VM in the developing status of Malaysia has not yet reached to its maturity, however the awareness regarding its increasing demand is getting attention in academic publications (Jaapar et al.; Jaapar & Torrence, 2006). This raise in the application of VW has led to the consideration of Malaysian construction sector as a suitable case study area for this research. All these case studies on actual projects in this section have been designed and conducted by the author himself.

4.2 Descriptive statistics of respondent survey data

The Survey succeeded in gathering the information and details on the current practice of VM in the Malaysian construction industry. The findings provided a holistic view of the VM application and experience was gained from the outcome of the survey. The results of the questions descriptive statistics is presented in the following.

4.2.1 Descriptive statistic for current profession

Table 4.1 and Figure 4.1 provide descriptive statistic (number and percent) for current profession.

Table 4.1
Number and Percent of Response for Current Profession

	N	%
Academician	3	3.1
Architect	4	4.1
Engineer	47	48.5
Management	19	19.6
Planner	2	2.1
Quantity Surveyor	11	11.3
Others	8	8.2
Engineer and Management	3	3.1
Total	97	100.0

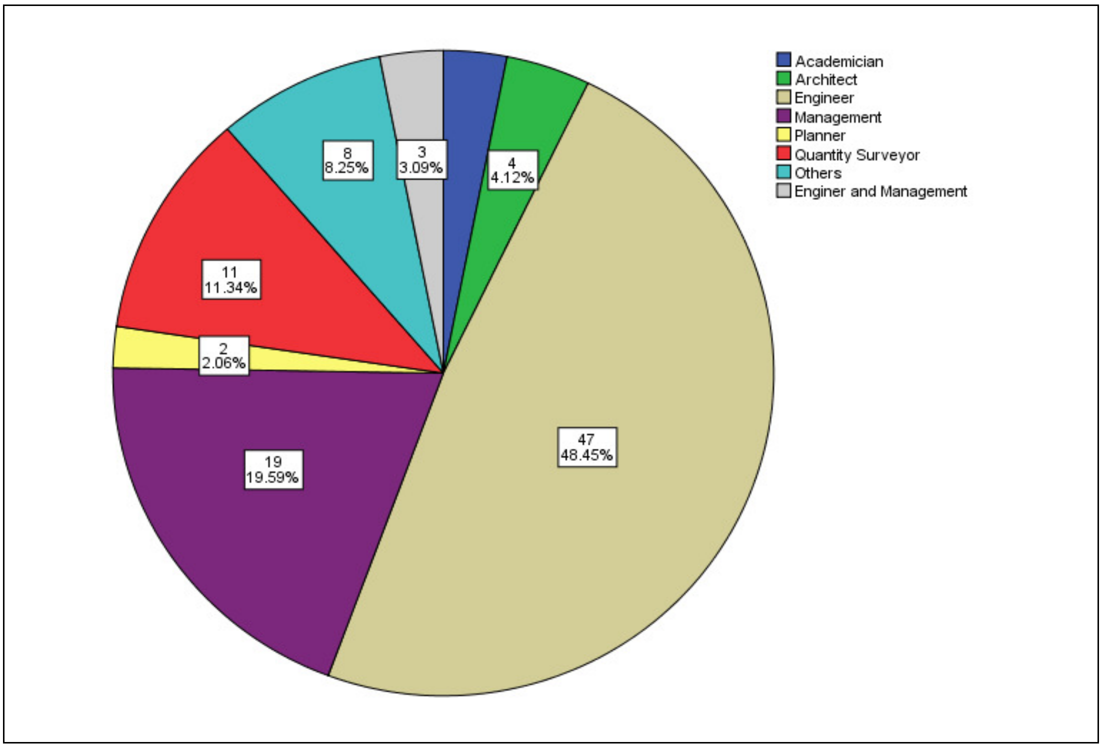

Figure 4.1
Number and percent of response for current profession

The greatest percent (48.45%) for current profession belongs to engineer; whereas the smallest percent goes to planner profession (2.06%).

4.2.2 Descriptive statistic for position in current company

Table 4.2 and Figure 4.2 present descriptive statistic (number and percent) for position in current company.

Table 4.2
Number and Percent of Response for Position in Current Company

	N	%
Director	18	18.6
Higher Management	19	19.6
Middle Management	28	28.9
Executive	21	21.6
Others	11	11.3
Total	97	100.0

As table shows, the biggest percent for current profession belongs to middle management (28.9%); whereas other positions item has the lowest percent (11.3%).

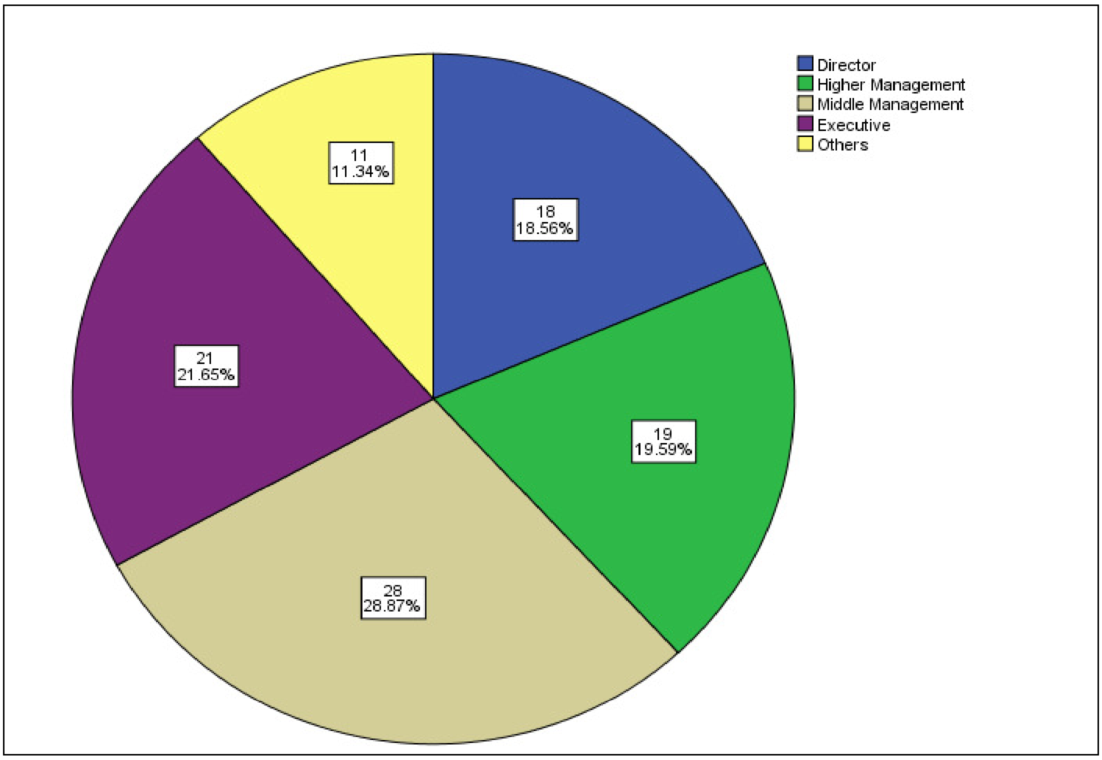

Figure 4.2
Number and percent of response for position in current company

4.2.3 Descriptive statistic for company nature of business

Table 4.3 and Figure 4.3 demonstrate descriptive statistic (number and percent) for company nature of business.

Table 4.3
Number and Percent of Response for Company Nature of Business

	N	%
Developer	28	28.9
Consultant	24	24.7
PMC	3	3.1
Education	3	3.1
Government Agency	4	4.1
Contractor	26	26.8
Developer and Government Agency	1	1.0
Developer and Contractor	6	6.2
PMC and Contractor	1	1.0
Developer, PMC, and Contractor	1	1.0
Total	97	100.0

As presented in the table, the highest percentage for current profession comes with developer (28.9%); whereas the smallest percent values appear with the individuals with more than one business, such as: developer and government agency (1%), PMC and contractor (1%), and developer, PMC, and contractor (1%).

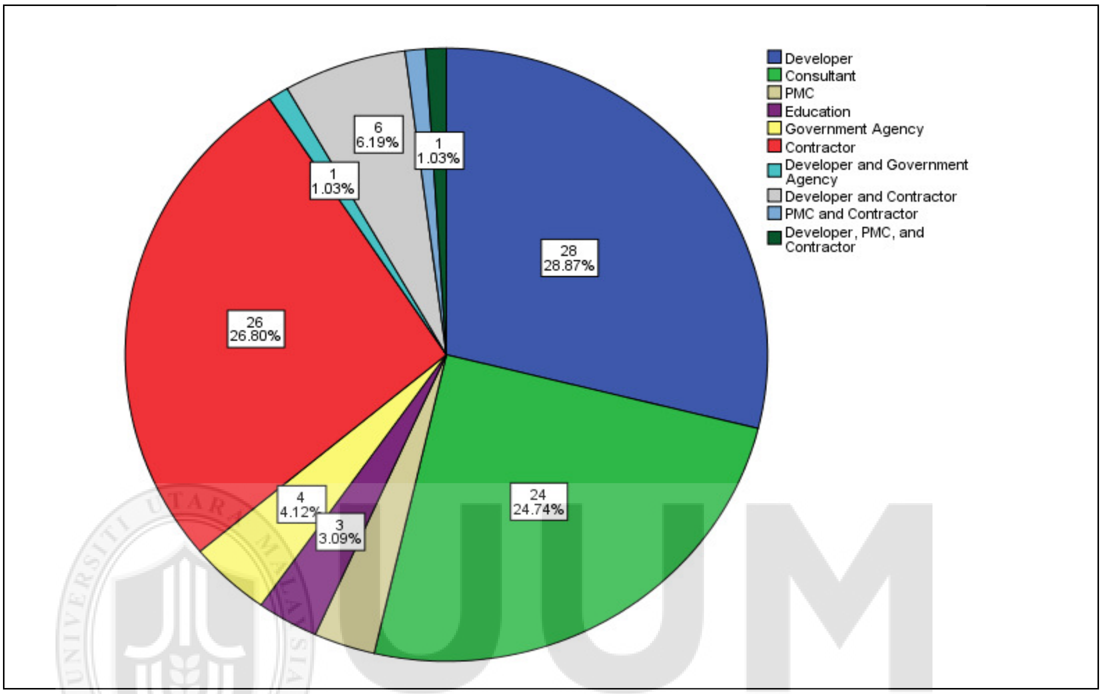

Figure 4.3
Number and percent of response for company nature of business

4.2.4 Descriptive statistic for highest qualification

Table 4.4 and Figure 4.4 show descriptive statistic (number and percent) for highest qualification.

Table 4.4
Number and Percent of Response for Highest Qualification

	N	%
Diploma	14	14.4
Advanced Diploma	6	6.2
Degree	53	54.6
Master	15	15.5
PhD	3	3.1
Professional Cert	3	3.1
Degree and Professional Cert	3	3.1
Total	97	100.0

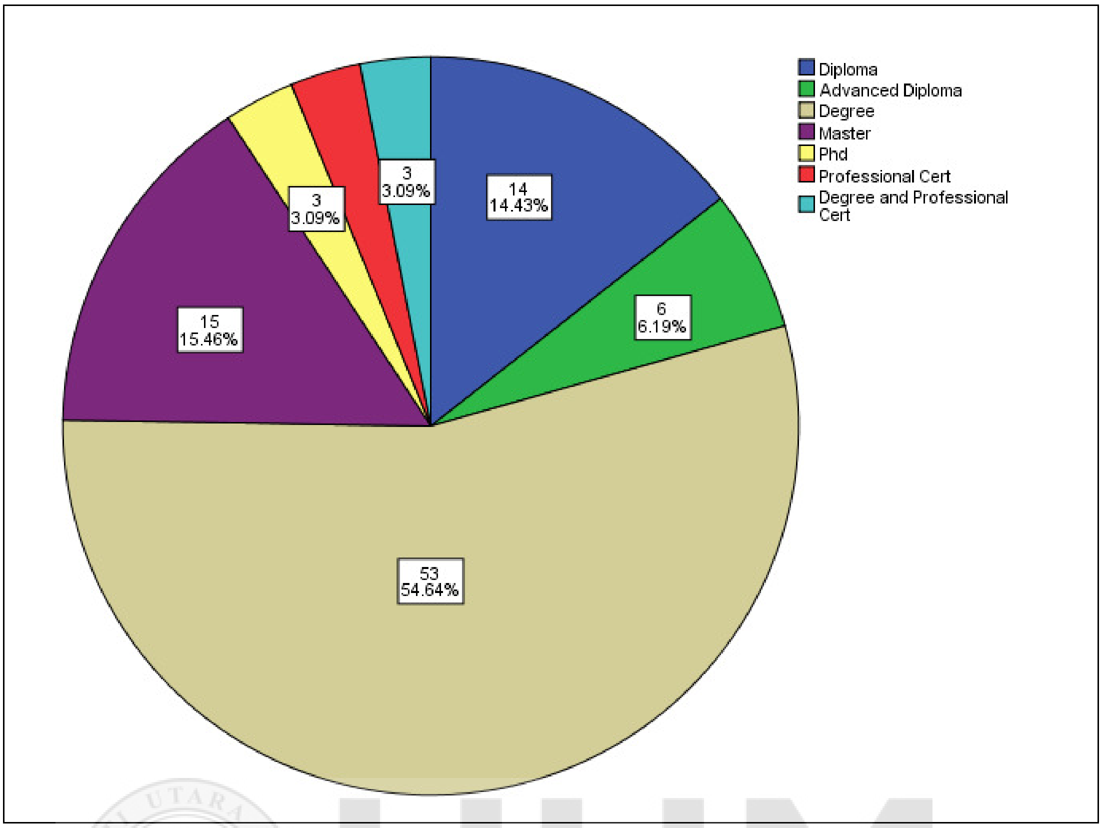

Figure 4.4
Number and percent of response for highest qualification

Results suggest that 54.6% (N=53) of respondents have degree certification; 14.4% (N=14) of respondents have diploma certification; 15.5% (N= 15) of respondents have master certification, 6.2% (N=6) of respondents have advanced diploma, and 3.1% of respondents have PhD, professional certification, and both degree and professional certification.

4.2.5 Descriptive statistic for field of study

Table 4.5 and Figure 4.5 illustrate descriptive statistic (number and percent) for field of study.

Table 4.5
Number and Percent of Response for Field of Study

	N	%
Business	1	1.0
Engineering	57	58.8
Management	7	7.2
Architectural	6	6.2
Planning	3	3.1
Quantity Surveyor	12	12.4
Others	3	3.1
Engineering and Management	6	6.2
Management and Quantity Surveyor	1	1.0
Architectural, Planning, and Quantity Surveyor	1	1.0
Total	97	100.0

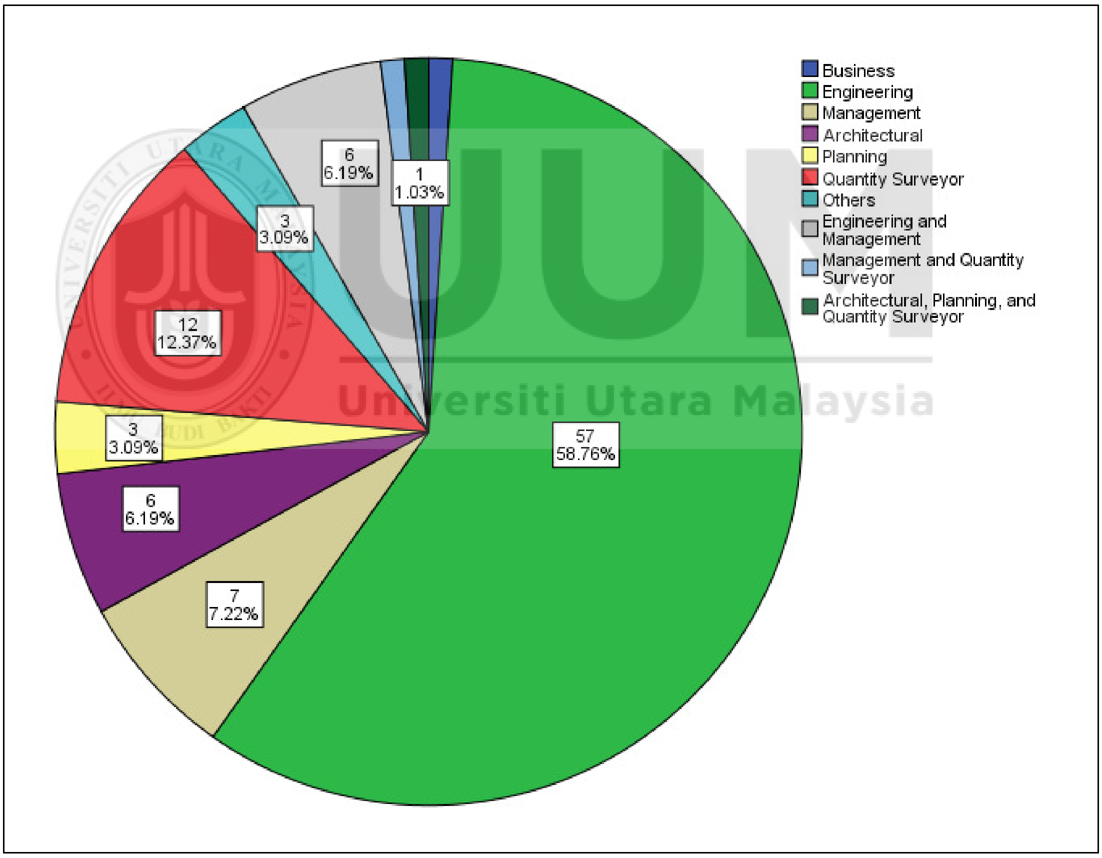

Figure 4.5
Number and percent of response for field of study

In terms of field of study, the majority of the respondents were engineers (58.8%), and 12.4% of respondents considered themselves as quantity surveyor.

4.2.6 Descriptive statistic for working experience

Table 4.6 and Figure 4.6 provide descriptive statistic (number and percent) for working experience.

Table 4.6
Number and Percent of Response for Working Experience

	N	%
1-5 years	11	11.3
5-10 years	17	17.5
10-15 years	20	20.6
15-20 years	49	50.5
Total	97	100.0

The findings show that 50.5% of respondents reported to have 15-20 years of experience of working; whereas 11.3% of respondents reported to have 1-5 years of working experience.

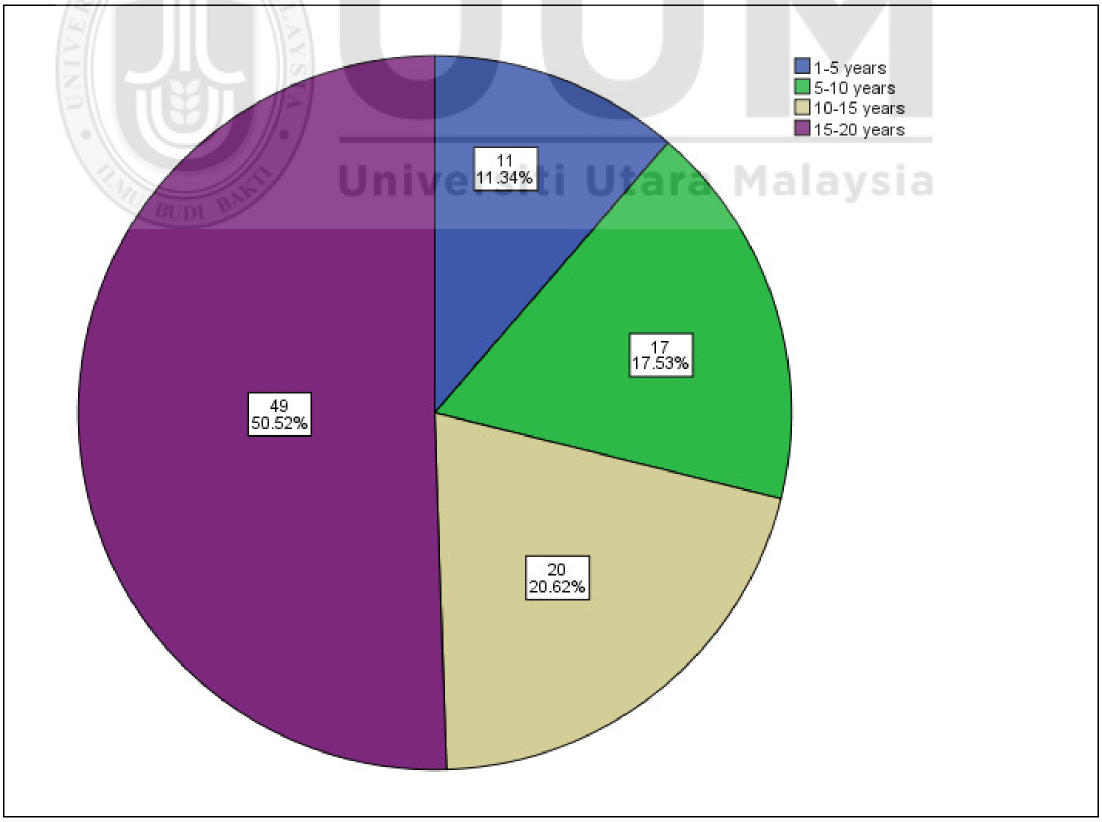

Figure 4.6
Number and percent of response for working experience

4.2.7 Descriptive statistic for years of experience in Value Management

Descriptive statistic (number and percent) for years of experience in VM is tabulated in Table 4.7 and further illustrated in Figure 4.7.

Table 4.7
Number and Percent of Response for Years of Experience In VM

	N	%
No experience	47	48.5
1-5 years	31	32.0
5-10 years	15	15.5
10-15 years	2	2.1
15-20 years	2	2.1
Total	97	100.0

The findings reveal that 48.5% of respondents have no experience, 32.0% of respondents reported to have 1-5 years of VM experience of working, and 15.46% of respondents reported to have 5-10 years of VM experience of working.

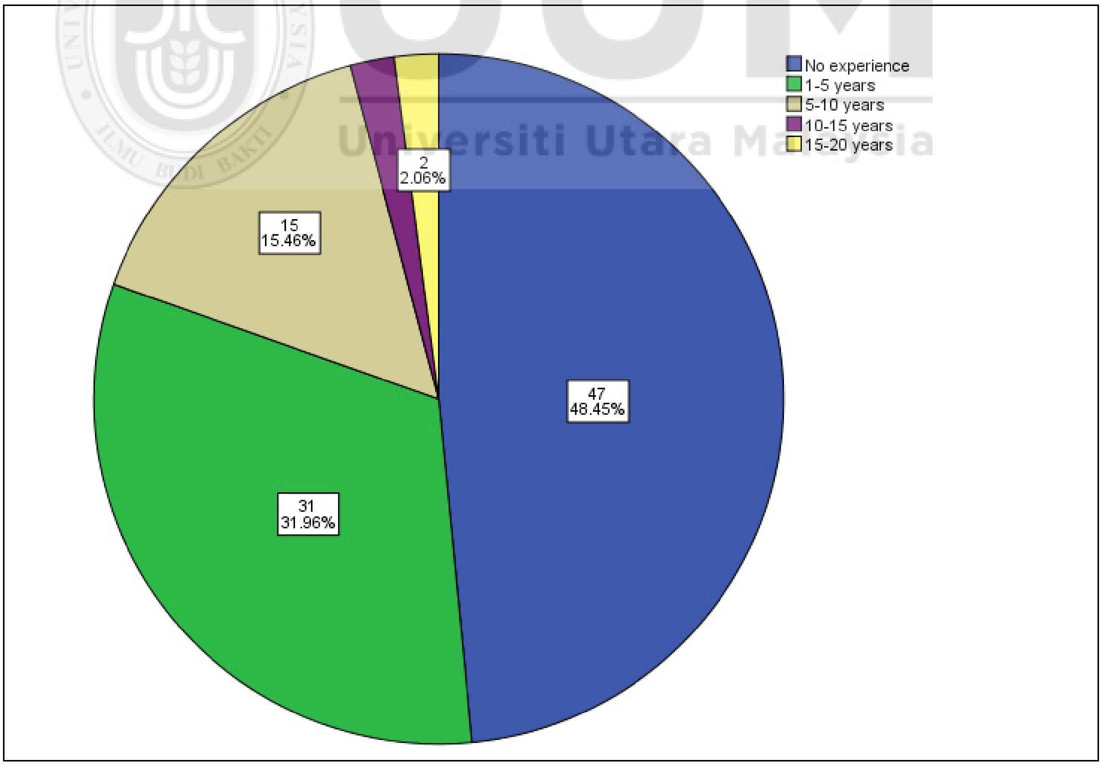

Figure 4.7
Number and percent of response for years of experience in VM

4.2.8 Descriptive statistic for attended VM course before

Figure 4.8 provides descriptive statistic (number and percent) for attended VM course before.

82.47% have not participated in the VM course; whereas 17.53% have participated in the VM course.

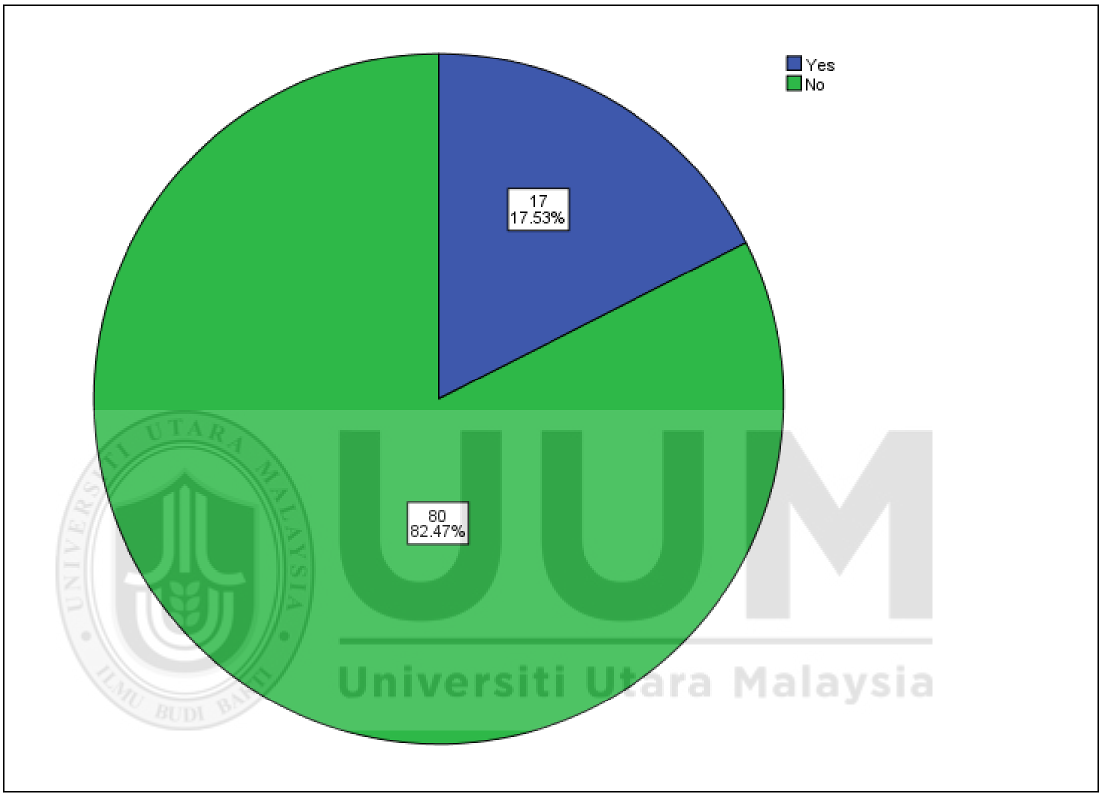

Figure 4.8
Number and percent of response for attended VM course before

4.2.9 Descriptive statistic for item "which is the best profession to apply VM"

Table 4.8 and Figure 4.9 depict descriptive statistic (number and percent) for item "which is the best profession to apply VM"

Table 4.8
Number and Percent of Response for Item "Which Is the Best Profession to Apply VM"

	N	%
Architect	9	9.3
Engineer	19	19.6
Project Management	29	29.9
Planner	1	1.0
Quantity Surveyor	5	5.2
Contractor	1	1.0
Architect and Engineer	2	2.1
Architect and Planner	1	1.0
Engineer and Project Management	3	3.1
Engineer and Quantity Surveyor	3	3.1
Engineer and Contractor	1	1.0
Project Management and Contractor	1	1.0
Architect, Engineer, and Project Management	1	1.0
Architect, Engineer, and Planner	1	1.0
Engineer, Project Management, Quantity Surveyor	2	2.1
Engineer, Project Management, Contractor	1	1.0
Engineer, Contractor, and Others	1	1.0
Project Management, Planner, and Quantity Surveyor	1	1.0
Architect, Engineer, P Management, and Q Surveyor	2	2.1
Architect, Engineer, P Management, and Contractor	1	1.0
Architect, Engineer, Planner, and Q Surveyor	1	1.0
Engineer, P Management, Q Surveyor, Contractor	2	2.1
Architect, Engineer, P Management, Planner, Q Surveyor	2	2.1
Architect, Engineer, P Management, Planner, Q Surveyor, Contractor	7	7.2
Total	97	100.0

The findings of the survey suggest that the preferable professions to apply VM are project Management (29.9%), engineer (19.6%), and architect (9.3%), respectively.

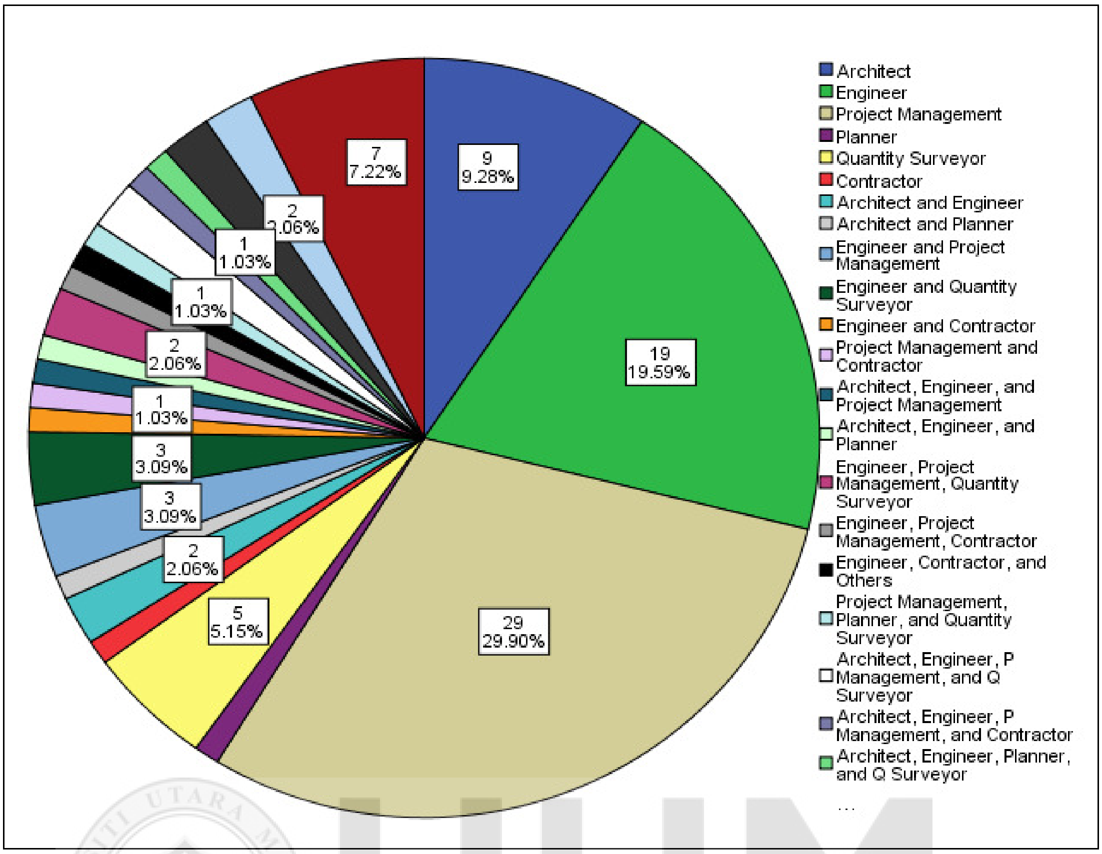

Figure 4.9
Number and percent of response for item "which is the best profession to apply VM"

4.2.10 Descriptive statistic for item "VM should be applied for construction projects Malaysia"

Table 4.9 and Figure 4.10 provide descriptive statistic (number and percent) for item "VM should be applied for construction projects Malaysia"

Table 4.9
Number and Percent of Response for Item "VM Should Be Applied for Construction Projects Malaysia"

	N	**%**
Strongly disagree	7	7.2
Disagree	4	4.1
Neutral	11	11.3
Agree	36	37.1
Strongly Agree	39	40.2
Total	97	100.0

In response to question "VM should be applied for construction projects Malaysia", 40.2% of respondents answer "*Strongly Agree*", and 37.1% of respondents answer "*Agree*".

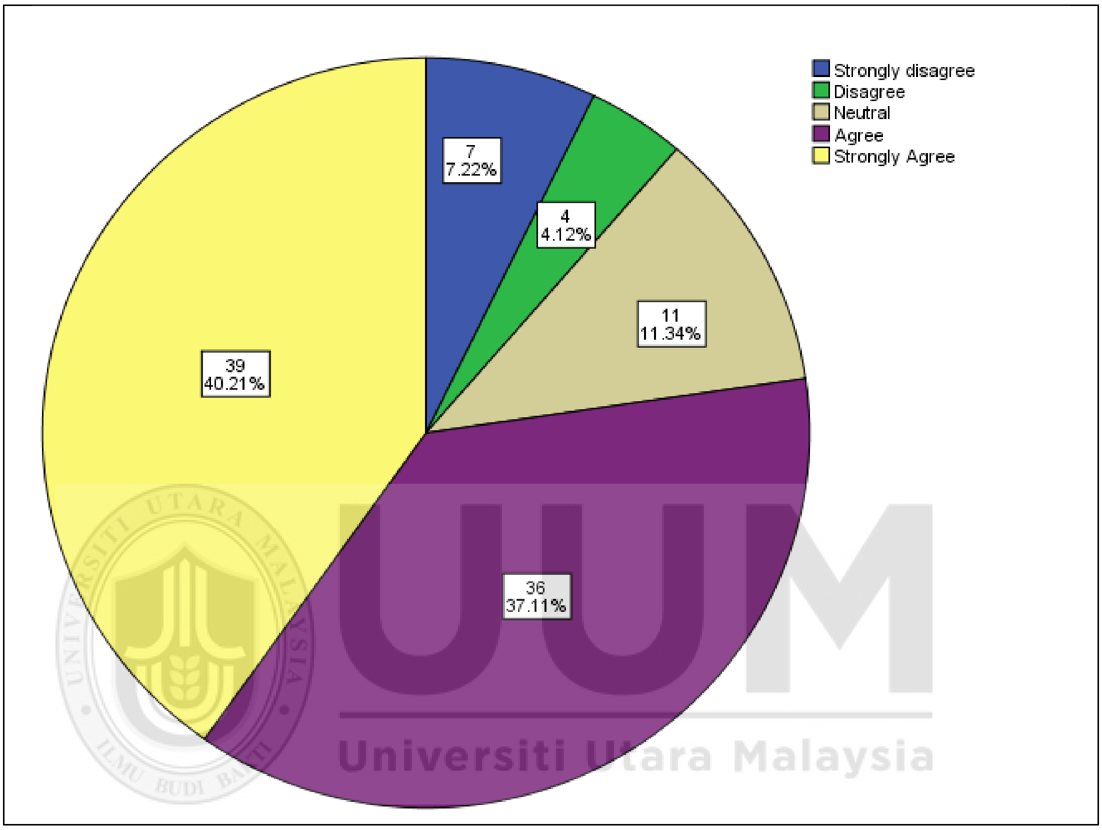

Figure 4.10
Number and percent of response for item "VM should be applied for construction projects Malaysia"

4.2.11 Descriptive statistic for items "Based on my understanding, these are the benefits of VM application."

Table 4.10 shows descriptive analysis for item "Based on understanding, these are the benefits of VM application."

Table 4.10

Descriptive Analysis of "Based on My Understanding, These Are the Benefits of VM Application."

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD[1]
Can reduce project cost	5	4	6	54	28	3.99	1.000
	5.2%	4.1%	6.2%	55.7%	28.9%		
Increase value to the project	4	6	19	52	16	3.72	0.955
	4.1%	6.2%	19.6%	53.6%	16.5%		
Can reduce wastage	3	2	11	65	16	3.92	0.799
	3.1%	2.1%	11.3%	67.0%	16.5%		
Can improve function and productivity	3	4	17	61	12	3.77	0.835
	3.1%	4.1%	17.5%	62.9%	12.4%		
Innovative design	4	2	27	50	14	3.70	0.892
	4.1%	2.1%	27.8%	51.5%	14.4%		
Others			7	8	2	3.71	0.686
			7.2	8.2	2.1		

1: Standard Deviation

On a 5-point scale, all items are marginally close to 4 (agree), indicating most respondents agreed to the benefits of VM application. In particular, 55.7% and 53.6% of the sample agreed to the statements *"VM application can reduce project cost"* and *"VM application increases value of the project"*. Interestingly, 67.0%, 62.9%, and 51.5% of the sample agreed to the statements *"VM application can reduce wastage", "VM application can improve function and productivity", and "VM application improves Innovative design".*

4.2.12 Descriptive statistic for items "Based on my experience, these are reasons of why VM is not well received in Malaysia."

Descriptive analysis for item "Based on my experience, these are reasons of why VM is not well received in Malaysia." is presented in Table 4.11.

Table 4.11
Descriptive Analysis of "Based on My Experience, These Are Reasons Of Why VM Is Not Well Received In Malaysia."

	Strongly disagree	Disagree	Neutral	Agree	Strongly Agree	Mean	SD
Lack of understanding of VM application	3 3.1%	3 3.1%	9 9.3%	61 62.9%	21 21.6%	3.97	0.852
Conflict of interest between stakeholders	3 3.1%	2 2.1%	23 23.7%	53 54.6%	16 16.5%	3.79	0.857
Lack of communication between all professions	3 3.1%	3 3.1%	12 12.4%	60 61.9%	19 19.6%	3.92	0.854
Lack of contractual provisions	2 2.1%	2 2.1%	13 13.4%	65 67.0%	15 15.5%	3.92	0.749
Difficulty in applying VM	2 2.1%	20 20.6%	19 19.6%	44 45.4%	12 12.4%	3.44	1.028
Others			2 2.1	3 3.1	2 2.1	4.00	0.816

On a 5-point scale, all items are marginally close to 4 (agree), indicating most respondents agreed to reasons of why VM is not well received in Malaysia". In particular, 62.9% and 54.6% of the sample agreed to the statements *"Lack of understanding of VM application"* and *"Conflict of interest between stakeholders"* respectively. Interestingly, 61.9%, 67.0%, and 45.4% of the sample agreed to the statements *"Lack of communication between all professions", "Lack of contractual provisions", and "Difficulty in applying VM"* respectively. Meanwhile, 3.1%, 2.1%, and 2.1% of the sample indicated that they were strongly disagree with the mentioned statements.

4.2.13 Descriptive statistic for items "VM should be included in university syllabus"

Table 4.12 and Figure 4.11 summarize respondents' responses to the statement: "VM should be included in university syllabus". 56.7% of sample reported that they agree to include VM in university syllabus.

Table 4.12
Descriptive Analysis of "VM Should Be Included in University Syllabus"

	N	%
Strongly disagree	2	2.1
Disagree	1	1.0
Neutral	12	12.4
Agree	55	56.7
Strongly Agree	27	27.8
Total	97	100.0

Meanwhile, only 1% of respondents disagree to include VM in university syllabus. The mean value and standard deviation values for this item were 4.07± .79.

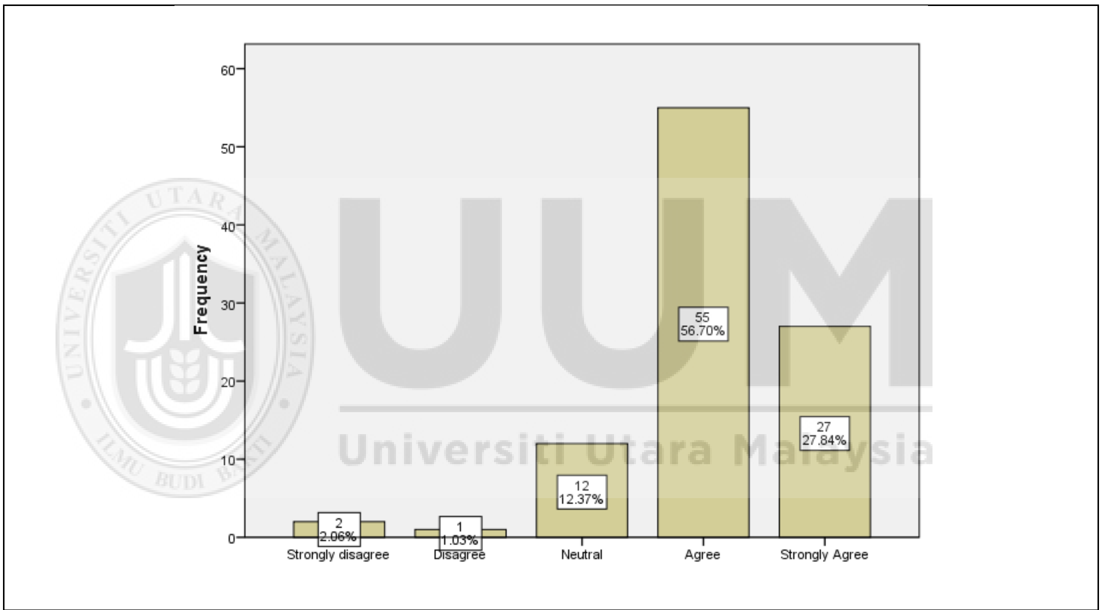

Figure 4.11
Number and percent of response for item "VM should be included in university syllabus"

4.2.14 Descriptive statistic for items "There is a bright future for VM"

As presented in Table 4.13 and Figure 4.12, 62.9% of sample reported that they agree to the statement "*There is a bright future for VM", and 21.6%* of sample respondents strongly agree with this statement.

Table 4.13
Descriptive Analysis of "There Is a Bright Future for VM"

	N	%
Strongly disagree	1	1.0
Disagree	1	1.0
Neutral	13	13.4
Agree	61	62.9
Strongly Agree	21	21.6
Total	97	100.0

The mean value and standard deviation values for this item were 4.03± .70.

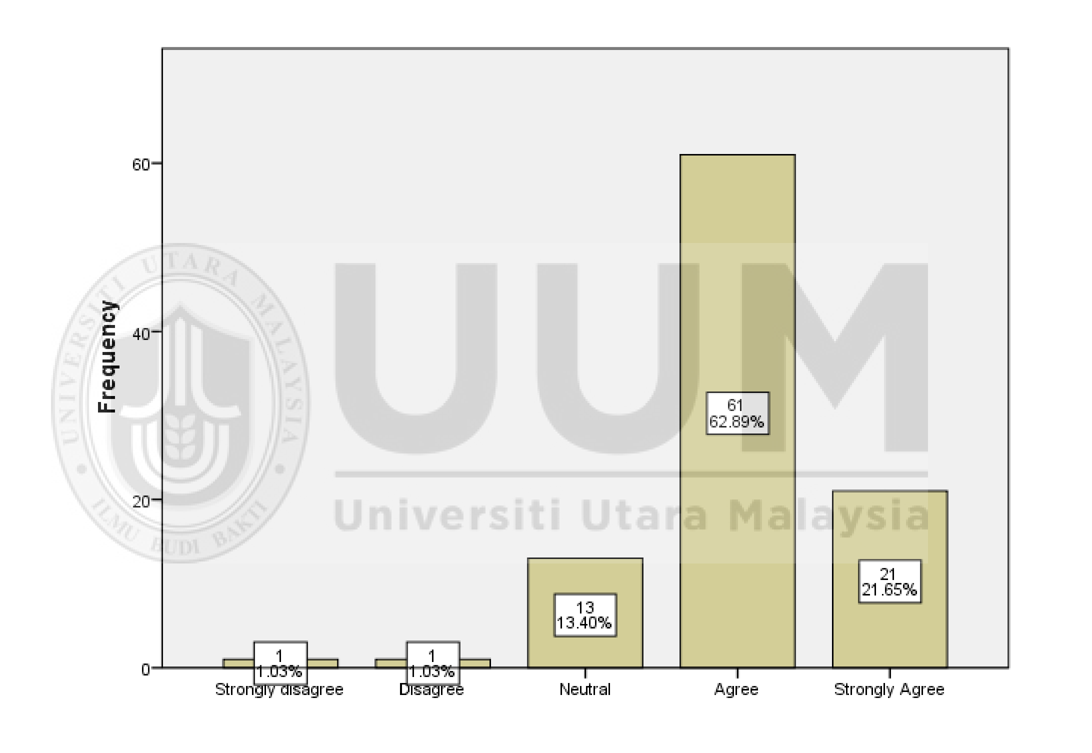

Figure 4.12
Number and percent of response for item "There is a bright future for VM"

4.2.15 Descriptive statistic for items "Will consider VM in my future projects"

As presented in Table 4.14 and Figure 4.13, 56.7% of sample reported that they agree to the statement *"Will consider VM in my future projects", and* 26.8% strongly agree with this statement. Meanwhile, *1% of* sample shows strong disagreement with this statement. The mean value and standard deviation value for this item were 4.05± .78.

Table 4.14
Descriptive Analysis of "Will Consider VM in My Future Projects"

	N	%
Strongly disagree	1	1.0
Disagree	3	3.1
Neutral	12	12.4
Agree	55	56.7
Strongly Agree	26	26.8
Total	97	100.0

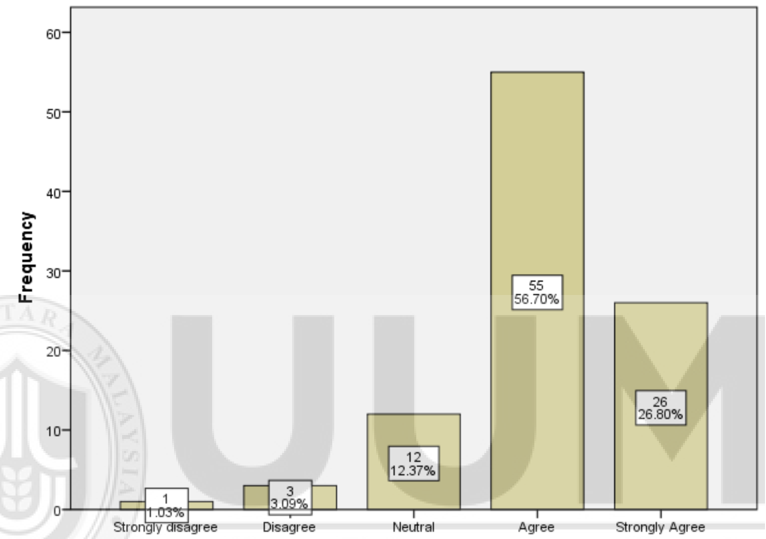

Figure 4.13
Number and percent of response for item "Will consider VM in my future projects."

4.3 Interview analysis

In order to obtain an in-depth understanding over the managing of design development by application of value management studies, the data gathered from the interviews which were carried out among seminar participants is analyzed in this section. To perform the data analysis, a qualitative approach known as Constant Comparative Analysis (Bryman, 2015) was utilized and coding of interview transcripts was carried out through NVivo Version 9. These analyze and results assist in organizing interview questions which pave the way to know about various concepts and ideas during the interviews.

4.3.1 Interviewee's profile

A total of 25 interviews were conducted to screen potential seminar participants. Table 4.15 indicates interviewee respondents' profiles:

Table 4.15
Interviewee's Profiles Registry

Ref	Interview ID	Background	Organization
1	INTV01	Civil Engineer	Consultant
2	INTV02	Civil Engineer	Consultant
3	INTV03	Quantity Surveyor	Client
4	INTV04	Civil Engineer	Consultant
5	INTV05	Management	Consultant
6	INTV06	Civil Engineer	Consultant
7	INTV07	Quantity Surveyor	Client
8	INTV08	Quantity Surveyor	Consultant
9	INTV09	Civil Engineer	Client
10	INTV010	Architect	Consultant
11	INTV011	Geotechnical Engineer	Client
12	INTV012	Quantity Surveyor	Client
13	INTV013	Civil Engineer	Consultant
14	INTV014	Architect	Consultant
15	INTV015	Architect	Consultant
16	INTV016	Management	Consultant
17	INTV017	Geotechnical Engineer	Client
18	INTV018	Quantity Surveyor	Client
19	INTV019	Civil Engineer	Client
20	INTV020	Architect	Consultant
21	INTV021	Architect	Consultant
22	INTV022	Quantity Surveyor	Consultant
23	INTV023	Quantity Surveyor	Client
24	INTV024	Civil Engineer	Consultant
25	INTV025	Management	Consultant

Based on Table 4.15, majority of respondents of the interviews (64%) was represented by the consultant team which was followed by the client team (36%). Hence, distribution of participants involved in a typical VM seminar was fair and this depicts a reasonably well-balanced achievable set of views.

4.3.2 Average interview duration

Among participants of the seminar in Kula Lumpur 25 interviews were totally carried out at the value management and value engineering level. As depicted in Figure 4.14, the interview duration varied ranging from 20 to 50 minutes.

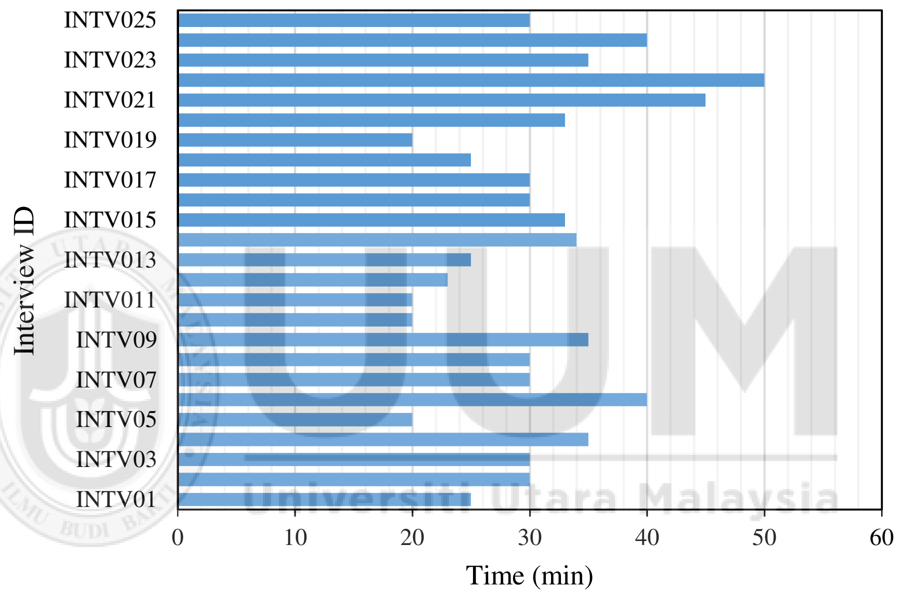

Figure 4.14
Average interview duration

4.3.3 Themes generated/data index

To perform the aforementioned analysis, all of the considered interviews were recorded and transcribed. In order to generate codes according to the transcripts the CCA method of the NVivo Version 9 was selected and some samples of interview transcripts with specific codes reflecting VM themes and other related data were assigned. To codify the generated 55 considered themes of these 25 interview transcripts, each code starts with the letter "DVM" followed by a specific number

(Table 4.16). It should be mentioned that in this CCA exercise, the codes are not according to any particular order of listing (i.e. ascending or descending).

Table 4.16
Themes Generated from Interview Transcript

Ref	Code	Themes
1	DVM01	Constructability
2	DVM02	Culture
3	DVM03	Participation
4	DVM04	Design constraints
5	DVM05	Value management in practice
6	DVM06	Creativity
7	DVM07	Seminar information
8	DVM08	Decision making
9	DVM09	Knowledge and experience
10	DVM10	System thinking
11	DVM11	Planning issue
12	DVM12	Construction process improvement
13	DVM13	Team representation
14	DVM14	Improvement in VM
15	DVM15	Multidisciplinary involvement in VM
16	DVM16	Benefit of VM
17	DVM17	Communication in seminar
18	DVM18	Perception in VM
19	DVM19	Reason for VM study
20	DVM20	Tools and techniques
21	DVM21	Team Cohesiveness
22	DVM22	Validation of information
23	DVM23	Timing of VM Seminar
24	DVM24	Control mechanism
25	DVM25	Facilitation
26	DVM26	Contractors involvement in VM
27	DVM27	Tacit Knowledge
28	DVM28	Institutionalised thinking
29	DVM29	VM study objectives
30	DVM30	Cost optimisation
31	DVM31	Explicit knowledge

Table 4.16, continued

33	DVM33	Visualisation aid
34	DVM34	Seminar
35	DVM35	Function analysis
36	DVM36	Information database
37	DVM37	Knowledge participants
38	DVM38	Experience of participants
39	DVM39	Limitation of VM
40	DVM40	Participant's attitude
41	DVM41	Skill of participants
42	DVM42	Control of seminar flow
43	DVM43	Changes after seminar
44	DVM44	Cost cutting
45	DVM45	Support documentation
46	DVM46	Authority in seminar
47	DVM47	Stereotype thinking
48	DVM48	Membership role in seminar
49	DVM49	Distributed information
50	DVM50	Presentation of participant
51	DVM51	External team
52	DVM52	Fee earning potential
53	DVM53	Value management and facilities management
54	DVM54	Client involvement
55	DVM55	Client authority in seminar

Research questions, research objectives and frequency of the themes were the factors that defined the main themes' relationship on which selection of the top ten themes as the main focus of this research was built. Nevertheless, to support findings, relationships amongst the remaining themes were not neglected and were taken into the analysis and discussions that follow. Table 4.17 indicates the selected top ten themes.

Table 4.17
Top 10 Related Themes

Ref	Code	Themes
1	DVM01	Constructability
2	DVM02	Culture
3	DVM03	Participation
4	DVM06	Creativity
5	DVM07	Seminar information
6	DVM08	Decision making
7	DVM09	Knowledge and experience
8	DVM10	System thinking
9	DVM24	Control mechanism
10	DVM33	Visualisation aid

In order to simplify the process of analysis, the top ten themes were further classified into two broad categories namely 'people' and 'system'. The first category 'people' corresponds to the themes and responses that represent human factors contributing to VM application in improving project designs. The second category 'system' describes themes and responses that root in procedural matters of VM. A summary of the categorization is displaced in Figure 4.15.

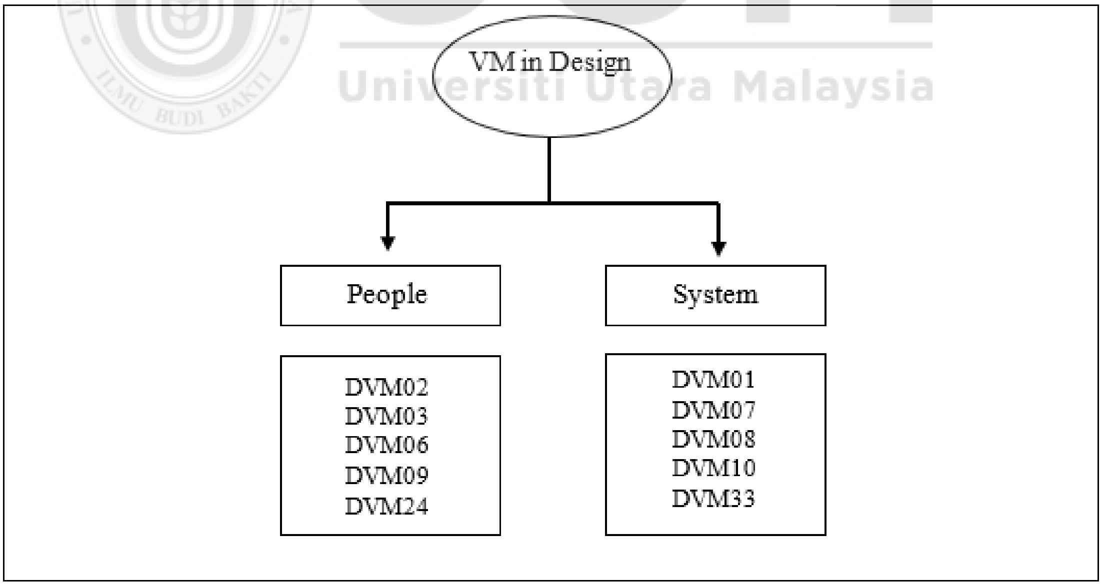

Figure 4.15
Themes categorization

In order to form a guide to the analysis process the research questions are repeated hereafter. The focus of these questions is on three concepts; involvement of participants and their corresponding factors which influence the participation, and the VM process for design development.

1. In a construction project how the process of design planning is performed through VM?

2. Which elements do affect decision-making process and human interaction of VM seminar participants?

3. How are the outcomes of the project design and planning affected by the multi-disciplinary participant involvement in a VM seminar?

4. How are the subsequent construction phases of a project impacted by these interactions and decision process through VM?

4.3.4 Themes Exploration 1: People Category

The people category deals with themes which are formed by interview with the aim of focusing on the people factor in VM. The following five themes belong to this category:

(i) DVM02 Culture

Deals with attributes of participant working styles, norms, behaviors, beliefs and habits correlated to the VM seminar.

(ii) DVM03 Participation

This theme refers to aspects describing seminar participants' level of involvement and participation during VM process. This encompasses social relationship, motivation, interaction and contribution among seminar team.

(iii) DVM06 Creativity

This theme refers to both creative thinking processes of participants and considerations that affect attitudes/behavior during the process of VM seminar.

(iv) DVM 09 Knowledge

Points out participants' levels of experience and knowledge that make difference to the VM process.

(v) DVM24 Control Mechanism

Refers to aspects such as participants' facilitation styles and management during the VM seminar process.

Responses of participants are explored in the following sub-section including verbatim quotations of the 25 interviews. Furthermore, to avoid lengthy list of quotes statements with similar nature were eliminated and a shortlist of verbatim excerpts of quotations was generated as a true representation of ideas taken from the analysis procedure. It should be mentioned that each considered theme includes several components known as first order concepts representing a subgroup within each theme.

4.3.4.1 DVM02 Culture

Two first order concepts namely 'institutionalized thinking' and 'personality' are included in this theme. The former one is associated with verbatim excerpts and concerns the way participant of each seminar reacts and thinks throughout the VM process. Majority of interviewees were observed to show institutionalized opinions concerning the seminars. This institutionalized thinking stands for seminar participants' statements representing the view of their own discipline (i.e. architectural, structural, surveyors, clients, etc). This means that each issue is viewed by participants based on both the interview questions asked and their attachment to specific professions or organizations.

Another issue observed amongst interviewees was Stereotypical thinking as some of them consider the VM as cost cutting tool rather than a technique to add value to projects. Table 4.18 depicts the observations related to this theme.

Table 4.18
DVM02 Culture-Institutionalized Thinking

First order concepts		Representative Quotations
Institutionalized attachment	1.1	Participants have different concerns, for example designers' concern is always the design concept while QS and Finance's main interest will be always Ringgit. However, respecting other professions in addition to noticing the same issue in the same mindset are the factors that all participants should be able to do. [INTV02]
	1.2	Designers happen to resist changing their design and they come up with several reasons to support that. I am pointing to major changes of a design. If I were in designers' shoes I would feel the same especially after months spent for all the handworks and research done to comply with project's standards. [INTV04]
	1.3	Participants are expert in the subject matter but they still support the VM as a cost cutting method. [INTV05]
	1.4	Architects may have their own perspective compared to client's imagination. Divergence in understanding is always there. [INTV07]
	1.5	I found my ideas being compared with cost implication every time I proposed one so I quit proposing any more. [INTV12]
	1.6	Some consultants make their point towards design and cost but somehow ignore the impact of their proposal on the building system integration. [INTV14]
	1.7	End-user representatives could be part of this study so that the design would not remain solely with consultants' interpretations of their requirements. [INTV18]

The fact that a variety of participants are present in a single room thinking about a single issue leads to inevitable divided seminar personality and consequently a mixture of both positive and a negative personality which drive the seminar. This second component reveals a view of the personality of the seminar experienced by the interviewees as seminar participants (Table 4.19). Resistance to change was reported to be a repeated issue in the seminar by several interviewees. This shows a refusal to accept design proposals and/or changes that potentially could assist in coming up with positive outcomes from the seminar for the project. A rebuttal statement regarding this issue was observed which claim that efforts to appreciate the uplift of projects among the involved consultants have failed. On the other side, a positive contribution concerning control of participants' discussions is given off by the facilitator whose role is to manage the entire seminar process.

Table 4.19
DVM02 Culture-Personality

First order concepts Representative Quotations		Representative Quotations
Personality	1.1	Amount of re-work required to comply with new changes is why the designer resist changing the design. [INTV03]
	1.2	The limitation we encountered was that our design proposed to the client was similar to that of architect but then divergent type of delivery existed. The architects' thought was seeking for a conceptual design following their ego so that they considered our design as a definite one. Therefore, we did not have any word regarding change in the design especially the architectural design. [INTV12]
	1.3	We would like to criticize the design but with presence of such architectural point of view following that ego in the client's side, the way to make our point was blocked and this is a constraint for us. [INTV14]
	1.4	It could be much better if participants attend with their mind open and their egos left behind. [INTV16]
	1.5	Among participants in this seminar some are dominating, who resist accepting another people's opinion. [INTV17]
	1.6	Some of the participants did not do any beneficial thing to improve the study outcome and just attended for sake of filling up the room. [INTV18]
	1.7	Clients were found really eager to achieve value for money for the package. No wonder they appointed experienced facilitator to guide our seminar process. [INTV19]
	1.8	Not necessarily because of facilitator experience and his charisma, I don't think this seminar is going to conclude a positive outcome. [INTV20]
	1.9	This seminar consists of well experienced consultant, however I think I fall behind the seminar's stream and just leave the presentation part to my boss and start with writing down the ideas. [INTV24]
	1.10	My facilitator managed the dynamic in our seminar very well despite some dominant participants' and their consultants' concerted effort to push for their own ideas. [INTV22]

The above analysis concludes that firstly, the institutional attachments of participant and secondly, the pressure to comply with one particular institutional influenced view of the focal problem being examined in the seminar highly, influence the cultural aspect of VM seminar in design planning. Contributions of individuals stay in their own professional responsibilities with minimal cross-profession reference. Therefore, individuals respect others' expertise levels and experience. Whereas irrespective of dominant participants' personal attributes, position or working experience, more respect is understood to be gaining from them for others. The former is a positive side of this culture aspect while the later is a limitation.

4.3.4.2 DVM03 Participation

This theme encompasses three first order components; ‘representation’, ‘limitation to participate’ and ‘involvement level’. As indicated in Table 4.20, the first component refers to the sufficiency of the representation in seminar. As highlighted by INTV03, existence of a balanced mix between technical and non-technical participants amongst all seminar attendances as well as accession of additional seminar members to enhance the VM process was agreed.

Table 4.20
DVM03 Participation – Representation

First order concepts		Representative Quotations
Representation	1.1	The argument running in this seminar is managed in a positive and dynamic way and different parties' contribution makes this seminar interesting. [INTV10]
	1.2	I see a mixture of technical and non-technical people in the VM study I am participating. [INTV09]
	1.4	All of the participants are subject matter expert so that accountability and transparency is obvious in the seminar. Presence of attendances with lesser level of experience can provide different perspective to the discussion. [INTV15]

The second component which is involvement level of seminar attendants refers to the combination of technical and non-technical participants (Table 4.21). This combination reported to furnish an extended insight into the issues discussed whereas in contrast to that, some of interviews hold out that involvement level had come to a challenging issue in keeping focus amongst seminar participants. Furthermore, according to INTV04 some of the interviewees highlighted experiencing an inability to transfer a clear message across the seminar. INTV22, however, finds VM as a way of promoting communication among participants and look into the seminar as an opportunity to discuss the project issues even if minimal interaction exists.

Table 4.21
DVM03 Participation - Involvement Level

First order concepts		Representative Quotations
Involvement level	1.1	When participation happens to be in and out and discussion is not followed it is difficult to get people to focus. You can contribute when you follow. [INTV02]
	1.2	Open communication takes place when you make an argument and properly share the knowledge you have. Otherwise, it is not an open communication. [INTV03]
	1.3	It can be seen that the issue under study relies on one specialist while representatives of other professionals are there to improve the quality of the discussion. Now the point is if that specialist cannot provide his expert consultation, what is the benefit of holding this VM study. [INTV04]
	1.4	Presence of technical and non-technical participants clearly makes the situation such that speaking on the technical language and posing questions which are not anticipated by technical team respectively form the overwhelming stream of the seminar. [INTV14]
	1.5	Participation of experts does not necessarily affect the current VM study, however their attendance can provide a strong basis of communication between participants and VM instructors. [INTV18]
	1.6	Having expertise on board while they have no relation to the project can ensure the effectiveness of the VM study. [INTV19]
	1.7	Before I ask my question, I should think whether it is acceptable among other participants. [INTV21]
	1.8	VM study paves the way to build communication as a project team although some of the members do not take part in the discussion. [INTV22]
	1.9	Participation of attendants in the talks depends on whether the issue falls within their responsibility. [INTV24]

'Limitation of participants to be involved' is the third component of this theme and lists a variety of limitations mentioned by interviewees (Table 4.22). Lack of understanding and preparation, difficulty to convince other people of one's own ideas, lacking or varying experience levels, fear of being judged and substitution of participants attending the seminar were of the most factors that limit participants' involvement.

Two broad categories can better clarify these limitations. The first category could refer to individuals within the seminar (i.e. lack of understanding and preparation, fear of being judged, difficulty to convince other people of one's own ideas, lacking or varying levels of experience). The second category originates in the system of the seminar itself (i.e. lack of understanding of participants) where difficulty in apperceiving information supplied during the seminar is experienced.

Table 4.22
DVM03 Participation - Limitation to Participate

First order concepts		Representative Quotations
Limitation to participate	1.1	I'd rather refer to their ability of recalling specific information, justifying recommendations by further referencing after the seminar may be because they are not ready or limited in experience. [INTV03]
	1.2	Junior staff should be accompanied by experienced seniors so that no risk of facing one expertise inputting less than others. [INTV06]
	1.3	I did not fully understand the required system because I saw myself in a seminar in which the project consultant was introducing design changes via an alternative system while no information, design or any alternative solution was given in the subsequent VM meeting. [INTV09]
	1.4	In my view, there is no deficiency with their knowledge or rather experience. The problem I think is the way they scatter their ideas and get people to agree with them. I sometimes find it disturbing. This is apart from expertise with good ideas but have difficulty to explain their thoughts and therefore leaving the space for others to lead the discussion to reach understanding. [INTV10]
	1.5	Being afraid of receiving comments regarding relevance of my idea to the subject issue or repetitive highlight from my side, I somehow resisted expressing my views. [INTV11]
	1.6	When participants are justified about their role in the seminar, seminar objectives and client's expectation, their participation and therefore contribution really benefits the discussion. [INTV13]
	1.7	Attendance of representatives instead of invited expertise may result in inadequate input. This can impact effectiveness of the seminar outcome. [INTV21]
	1.8	The overwhelming mentality of them is the idea of VM a cost cutting method, despite all the teams are sharing their best knowledge and experiences. [INTV24]
	1.9	I found it difficult to understand and follow the design briefing presented by consultants so I lost my interest to contribute. [INTV20]

Multi-disciplinary participation and involvement clearly result in a wider perspective of design planning issues, however the analysis concludes that the existing VM practice needs further improvement. The time constraints didn't impact the participation level despite the negative expressed connotations. An inevitable fact during design planning seminar especially when a complex project is involved is involvement of technical and non-technical participants, hence to ensure a proper streamlining of information provided for both technical and non-technical attendants further attention should be paid.

4.3.4.3 DVM06 Creativity

Creativity theme as presented in Table 4.23 and Table 4.24 includes two first order components; 'exploring creativity' and 'distraction to creativity'. As highlighted by interviewees the creative thinking processes were generally positive. The positive attributes cited by the interviewees were 'freedom to express views' and 'replicating past experience in current issues' along with 'plenty of space for exploration'. Based on the INTV15, another contributing factor to the creative process found to be the multiple backgrounds of respondents at seminar. Due to lack of direct reference regarding the application of specific techniques or tools, full participants' satisfaction about enhancement of their creativity cannot be concluded.

Table 4.23
DVM06 Creativity - Exploring Creativity

First order concepts		Representative Quotations
Exploring creativity	1.1	I believe that creativity is not limited in designer's hand. [INTV02]
	1.2	I have to change my role so that I can improve my position rather than my background. [INTV10]
	1.3	Combination of experienced people in a seminar like this one to solve a problem is amazing since lots of great ideas can be generated and then mixed to find a superior solution. This is viable when each participant has his/her own experience and strength applied to actively play an efficient role. [INTV16]

Table 4.23, continued

	1.4	I see them highlighting some areas but bearing in mind the expectations from a VM seminar, they lack contribution, i.e. no talk about a new alternative option or methodology. This is not the way we can benefit from VM study. [INTV17]
	1.5	I'm willing to input my past experience to solve design problems. [INTV18]
	1.6	With lack of solid evidence, it is hard to visualize the change made in the design. [INTV20]
	1.7	My way of contribution is following the stream of the VM seminar but when accompanied by a facilitator or an active team mate, my thinking process will spark and I can get involved with the discussion. [INTV21]
	1.8	I faced tough time for grasping and visualizing the plan and then turning it into 3D, so I just preferred to visualize myself up and running in that space. [INTV21]

The second component of the creativity theme is 'distraction to creativity' which refers to blocking participant creative thinking processes and it spans across both people factors and the existing seminar system. The former factor covers personal attributes of individuals where the way others read language of body and gestures during presentation, shyness to speak in public and position within the company and over-dominant participants have influences on participant's creative thinking. The later factor focuses on control issues of the seminar such as complexity of issues and discussion structure and method of presenting information. As cited by most interviewees, these items make a difference to the level of understanding, concentration and motivation towards creativity of seminar attendants.

Table 4.24
DVM06 Creativity - Distraction to Creativity

First order concepts		**Representative Quotations**
Distraction to creativity	1.1	The presented information is complex and participants are confused especially with the way it is presented. [INTV04]
	1.2	Participants are coming and going for coffee break and washroom and it is difficult for me to focus during the seminar or have it back on track. [INTV10]
	1.3	Without being properly clarified regarding the boundary of the issue and respective exploration, the approach of the seminar looks like a brainstorm. This is in addition to constantly giving ideas. Revision or applying other techniques is required. [INTV12]

Table 4.24, continued

	1.4	Despite the prohibition to judge ‘verbally’, our body language and gestures somehow indicate that some ideas are actually bad! [INTV17]
	1.5	I prefer to leave the talk to my experienced boss. [INTV18]
	1.6	Sitting among experienced consultants makes me a little scared and I'd rather watch the stream of the seminar. [INTV19]
	1.7	When all participants are given the opportunity to voice their ideas, I think it is a hindrance to come up with creativity in such a brainstorming atmosphere. You probably think that others have already taken your ideas and sent you back to square one and you have to think about new ideas again. [INTV21]

This analysis shows that to support the creative thinking process, the most frequently applied technique across all the seminar participants is brainstorming technique which provides too much freedom for generating ideas by the participants such that may ultimately prove to be less effective. That is why some form of guidance, structure or a framework for creative thinking is on demand, especially when a project is too complex in nature, so that respondents could be as creative as possible during the use of this technique. Noting that agglomeration of a quantity of ideas was not reported a great concern amongst seminar participants, it was perceived that requiring a set of guidelines should not mean to restrict ideas generated but to set the limits on how focused solutions can be produced. These are the concerns experienced by the participants in spite of continuous utilization of this technique.

4.3.4.4 DVM09 Knowledge and experience

The knowledge and experience theme includes four first order concepts namely ‘experience level’, ‘refresher course’, ‘functional analysis technique’ and ‘knowledge sharing’. Similar issues were often mentioned by interviewees but a selection of the interview process is given in Table 4.25 to demonstrate how respondents comprehended these concepts and issues. Although participants had generally acknowledged that they have adequate knowledge and experience level possessed by each seminar participant, based on some interviewees [INTV22 and 24], some of the participants still believed that undertaking refresher courses of VM was important for them and tried to promote the need for refresher courses on VM mostly because of difficulty to interpret and grasp what is going on during the VM process [INTV15, 20 and 22]. In addition, it was also claimed that functional analysis is facilitator's job [INTV15, 22 and 23]. The necessity for more knowledge sharing was an issue raised by an interviewee facing attendance of junior staff in the seminar [INTV17]. This was because of participation of people with lesser working experience but with new perspectives in the seminar and therefore producing new creative ideas.

Table 4.25
DVM09 Knowledge and Experience

First order concepts		**Representative Quotations**
Experience level	1.1	In my view, there is no deficiency with their knowledge or rather experience. The problem I think is the way they scatter their ideas and get people to agree with them as if their ideas worth than the others. I sometimes find it disturbing. This is apart from expertise with good ideas but have difficulty to explain their thoughts and therefore leaving the space for others to lead the discussion to reach understanding. [INTV09]
	1.2	Knowledge and experience of participants clearly has a key role in improving the quality of the VM study and consequently the outcome. [INTV10]
	1.3	I think participants are required to be subject matter experts with ability to express their view point, highlight them and persuade people to talk about their thoughts. [INTV15]
Refresher course	1.4	Participants should grasp the importance of VM. So, a refreshing program should be managed in a continuous way. [INTV22]
	1.5	I need introduction course for better understanding of the way VM works and the entire process of the study. [INTV24]
	1.6	I'm not graduated in VM field and all I could learn about VM was via attending similar VM seminars and experiencing in practice. [INTV05]
Knowledge sharing	1.8	I believe that participants with low level of experience may attend the discussion with various and different perspectives which can improve the stream of the seminar and facilitate transfer of knowledge from senior to junior staffs. In this way, naive questions of juniors regarding design can be answered professionally. [INTV25]
Function analysis	1.9	I still have no idea how it works. [INTV20]

Table 4.25, continued

	1.10	At the time of function analysis, I just prefer to follow the facilitator's instruction. [INTV15]
	1.11	I look into the function analysis as a powerful tool which should be interpreted correctly. [INTV22]
	1.12	Producing the function analysis is, in our view, an expert's job and we leave to facilitator and our role is just feeding in the information. [INTV23]

Comprehension of VM processes and techniques utilized was the only exception with regard to knowledge attributes. Due to lack of knowledge many respondents experienced difficulty with application and of course making sense of functional analysis as a method for them to apprehend the flow of the seminar. Therefore, it was left to a facilitator to lead so that they can follow the lead. This result is analogous to that found by Ellis et al. (2005) in the UK and Spaulding et al. (2005) in Australia. It is noteworthy to mention that the appreciation of functional analysis and the way it works relies on individual's capacity itself (SAVE International). Further analysis showed that the difficulty in comprehending functional analysis experienced by majority of respondents had also originated from the external VM team.

4.3.4.5 DVM24 Control Mechanism

This theme contains only a single first order component which is 'discussion framework' (Table 4.26). Mechanism of reviewing designs and discussion structure within the seminar environment were the issues about which interviewees were concerned. In fact, the critical issue encountered by interviewees was an improper control mechanism of participants' involvement in discussions and review designs. On the other hand, importance of an efficient structure which sets the boundaries for discussion was focused by a large number of responses within this theme.

Table 4.26

DVM 24 Control Mechanism

First order concepts		Representative Quotations
Discussion framework	1.1	Control mechanism refers to controlling thoughts of experienced consultants towards decision making without jeopardizing their reputations. Since they have their own egos, therefore this needs skillful facilitator to manage it and to bring out the best from them. [INTV02]
	1.2	In absence of a structured framework on where discussion is leading to, discussing about design is tough. [INTV06]
	1.3	Review mechanism allows recommendation and implementation of certain things. [INTV24]
	1.4	Design development review is what a constructability list should be able to guide. [INTV20]
	1.5	To ensure that we are not wasting our time and we are going to execute the outcome, we should follow up the recommendation made from the seminar. [INTV21]
	1.6	I see no structured guide to assist our discussion on design. The whole focus was how to reduce the project cost in the design stage. [INTV22]
	1.7	There are plenty of ideas running in the seminar and going wild beyond imagination but they are not effectively managed due to lack of a structured framework to set the boundary of our discussion. This is encouraging but not efficient. [INTV11]

This analysis demonstrates that the need of better structure conducts VM. A high level of strategic thinking is required for the complex task of design planning while ensuring that nothing is missed out from the planning. That is why mastering appropriate approach, tools and techniques for particular kinds of value studies is a crucial issue to ensure better control outcomes.

The analysis of interview responses for the category of 'people' with respect to VM application is summarized in this section along with five themes which focus on the people aspect and influence the manage of VM seminar. The first order concepts generated by this theme were all analyzed and positive observations were on all themes were recorded. More attention for issues such as participation style, control mechanism, VM knowledge and team interaction is on demand.

The following sub-section will discuss and analyze interviews placed under the category of system of VM seminar application.

4.3.5 Themes Exploration 2: System Category

In exploring the system category' theme, methodology and procedures to VM are the issues focused by research question. Responses gathered from the interviews address the research question. This category encompasses five themes described in the following:

(i) DVM01 Constructability

Refers to aspects of approaches and procedures utilized in design development practices via VM process.

(ii) DVM07 Seminar information

Aspects of VM seminar information are referred in terms of timing of distribution, sufficiency, quality and form that impact participants' processes and creativity in decision-making.

(iii) DVM08 Decision making

Traces attributes related to decision-making processes of VM seminar participants and factors influencing those processes.

(iv) DVM10 System thinking

Observed systems thinking approach during the VM seminar process are referred by this theme.

(v) DVM33 Visualization

In order to visualize ideas and design during VM process, aspects such as tools and approaches are referred by this theme.

4.3.5.1 DVM01 Constructability

Three majors first order concepts of 'buildability', 'multiple views in design' and 'application of VM in design' are included in this theme. The analysis carried out among interviewees regarding application of VM in design depicts that majority of them indicated positive responses. VM was found to be a suitable intervention to debate advances and to generate a way of communication among parties related to the construction project. According to INTV04, 05, 08, 10 and 12, many improvements in design could be achieved through application of VM. These advances are in terms of improved mechanical and electrical systems, better ergonomics of design, better space functions, streamlining of forms, IT integration, enhanced specifications etc. Some interviewees also cited that a greater shared understanding between architects and clients could be obtained through application of VM in design with the chance for a second overview of the design [INTV08 and 11].

It is notably observed that benefits of VM in producing design improvement were totally appreciated by majority of participants, contrarily an interviewee had a different point of view [INTV05]. This interviewee believed that design development should not be categorized under VM initiative title as the participants of seminar could be left spending hours attempting to discover alternative solutions based on no formal framework of decision or without having a specific focus. Respondents' views regarding application of VM in design are presented in Table 4.27.

Table 4.27
DVM01 Design Development - Application of VM In Design

First order concepts		Representative Quotations
Application of VM in design	1.1	Improving construction on-site at planning level of the project is helpful but in order to be able to do so and to solve issues first-hand information is necessary which has to be gathered by people working on-site. VM is the best choice for achieving suitability of the design in terms of forms, electrical and mechanical installation system and specifications. [INTV02]
	1.2	I believe VM is the best tool for those clients who seek for suitability of the design in terms of the mechanical and electrical system, specification etc. [INTV04]
	1.3	VM is being looked as one way capable of improving the outcome of the project. To get functional project lined up with the approved budget VM is a good choice. [INTV05]

Table 4.27, continued

	1.4	With all my experience, decision making platform is a key element for next course of action and assists top management to make proper decisions around the recommendation. [INTV11]
	1.5	VM can address the divergence and disparity existing between architects' and clients' understanding of the project. Inconsistency between understanding of the objectives and the project requirement. [INTV08]
	1.6	What I can gather from the study is that the main focus of VM is on finding alternative ways of substitution for design, e.g. material selection rather than design reduction. [INTV08]
	1.7	We can decide to make any changes, so why not encouraging others to reconsider the design. [INTV11]
	1.8	We can add value to the project by skimming down the design first but later adding up. [INTV10]
Contradicting views	1.9	In order to review the design in a proper manner we need a structured mechanism. Normally, we seek for opportunities to improve the drawings instead of having a proper framework to guide us, e.g. a constructability checklist. [INTV05]

The acknowledged benefit of application of VM for design development was discussed in the previous analysis (Table 4.28). To further justify this result the second theme, which is multiple views, is brought to bear on the design where majority of respondents gave analogous observations. In the participants' professional opinion, creation of new ways of doing things is a key issue in VM application and it indicates that there is more than a single way of achieving/doing thing. Proper mix of participants with various view pints, experiences and knowledge and getting involved in such process leads to a knowledge and experience-based advantage which allows VM to accordingly expand designs built on various professional backgrounds. As cited in INTV21, such multiple professional views can support and extend those technical areas in the design development beyond facilitator’s ability to handle technical issues. Furthermore, existence of this multi-disciplinary representation in the VM seminar firstly furnishes VM with a major selling point and makes it relevant for design development and secondly provides the opportunity to review and discuss design through VM along with a healthy interaction amongst participants and makes the knowledge sharing possible which would never happen in an otherwise isolated working condition.

Table 4.28
DVM01 Design Development - Multiple Views in Design

First order concepts		Representative Quotations
Multiple views in design	1.1	The design made by designers is built upon their own interpretation of the project which is then translated into specific form. I think this design is not standalone and the client or consultants should evaluate it from different angles. This is because they have their own system of design integration to incorporate with the main design. [INTV01]
	1.2	Designers keep their aesthetical point of view which can be assisted to integrate into a bigger picture and to clarify how the design will work. Seeking for reasons behind the design makes us convinced with it. [INTV11]
	1.3	Messages and concepts included in a design are carried in the design itself and kept in designers' mind. It is through VM that we question them on their design to understand and clarify what we are getting from the design. [INTV18]
	1.4	All participants are expert in their field and everyone declares his/her interpretation. We will eventually decide during the seminar. [INTV20]
	1.5	We can decide to make any changes, so why not encouraging others to reconsider the design. [INTV04]
	1.6	The necessary suggestions for betterment of the design and allocated space will be given by participants after being presented for the designed space in the seminar. [INTV05]
	1.7	Suggestions may cause others to come up with beneficial solutions for expertise. Most of VM seminars are held focusing on optimization of project cost as the key objective and I think it should be appreciated by participants. [INTV07]
	1.8	It is more practical when there is similar design with different delivery. The new design was considered as a limitation in our team in my client's view. Architect has his own ego and thinks of the main design as definite not a conceptual one. Therefore, no space left to change the architectural design. [INTV22]
	1.9	What I see is the avenue for appreciating construction process and feeling more sensitive when legal issues of construction project are dealt with. [INTV24]
	1.10	They mostly tend to participate in VM seminar to experience different kinds of views and ideas. [INTV12]

As given in Table 4.29, presence of multiple viewpoints was strongly recommended by interviewees who were concerned about buildability of the design. Integration of constructability information in the design takes place under divergence of design and construction phases [INTV14]. However, no observation and reference was made by interviewees on how existing techniques and tools applied in VM can assist with design development of their current project packages [INTV20 and 21]. Other alternatives known as constructability reviews were also discussed [INTV05 and 15].

Table 4.29
DVM01 Design Development – Constructability

First order concepts		Representative Quotations
Buildability	1.1	We are concerned whether it is possible to create the design. [INTV02]
	1.2	We evaluate the views and ideas in VM, therefore in case of rejection of a proposed idea the reason behind it is clear and the proposer will not prejudge. [INTV11]
	1.3	Sometimes additional work is required at the site condition to be prepared for a design. This extra work may be minor with minimal cost which is fine and therefore VO will be issued. However, in case of major preparation like redirecting underground services story is totally different and challenging. [INTV14]
	1.4	The seminar is programmed such that participants are divided into separate rooms to discuss trades separately, e.g. architectural or costing etc. I think this impacts the dynamic of discussion since each room consists of similar backgrounds. [INTV17]
	1.5	Segmentation into separate rooms is problematic since we cannot bring each trade expertise up to speed regarding the decisions made. We don't have the runner. [INTV20]
	1.6	Our company has asked a construction specialist to join us in the seminar to provide us with his expert judgment on the constructability of the design. He is not involved with the project but he can assist us to improve our team's competitive advantage for this project. [INTV13]
	1.7	By Being reinforced with a structured framework of design study we can reach to a more relevant proposal. [INTV15]
	1.8	Absence of a properly structured mechanism to review the design does not create an efficient atmosphere to improve the design. This is taking place in this VM seminar where we normally come up with improvements in the drawings with no proper guiding framework like a constructability checklist. [INTV05]

Application of this attribute leads to two major finding; firstly, the inclusion of internal or external construction experts in the study team and secondly the suggestion of structured constructability guidelines during the VM seminar process. The first outcome raises the chances of receiving feedback associated with value-added constructability. Despite the argue made by the participants regarding high expertise level in their own fields, results of the participation attribute indicate a variance to this notion. This highlight gathering, discussing and using design information during the seminar process. Therefore, review of limit, boundary and attributes that is accordingly set is a prerequisite. Whenever a 'live' document is meant to be a guide, not as a 'one-size-fits-all' document of course, for development of decisions and discussion, such infusions are correspondingly subjective. Hence, both suggestions are considered as a suitable point to start toward improvement of current VM practices.

4.3.5.2 DVM33 Visualization

This theme encompasses two first order concepts; 'visualisation constraints' and 'real-time information' as presented in Table (4.30). A major limitation in the seminar process as cited by the interviewees was difficulties to comprehend distributed presentations and drawings and subsequently encountering obstacles in making full use of them to reach to creative decisions [INTV02, 04, 05 and 25]. The general view of majority of the participants was that there was still room for further improvement of handed information in terms of the quality of information and mode of its presentation in the seminar [INTV16].

Table 4.30
DVM33 Visualization – Constraints

First order concepts		Representative Quotations
Constraints	1.1	We don't see any VM guideline through which we can run project investment especially at design stage. I just contribute and speak of my view point when I'm asked for it due to the complexity of the design. [INTV02]
	1.2	Based on my understanding, some improvement and modification on presentation of information could assist me to contribute more. It is quite tough for me to understand how a construction goes on just by looking at the section and plan. Maybe I don't have enough experience and this is limiting me. If this is the reason I'd rather keep quiet. [INTV04]
	1.3	I have no idea about the presented design information. [INTV05]
	1.4	A plan along with a section was given to us as the main question of the discussion and we were asked to reduce the cost through trimming down the design. The question may be clear but it turns to be a trouble when we are not that much familiar with design and we have never been into visualizing it so far. [INTV25]
	1.5	It would be better to have a 3D walkthrough since I should spend considerable time just to visualize the plan. Besides, I'm facing section drawings and plan for which I need more time to study the design. [INTV16]

Table 4.31 presents plenty of discussion points and suggestions cited by interviewees with regard to visualization constraints and distribution of real-time information. It was declared that it would be beneficial to have more simplified forms of information, ranging from effective presentation methods to introducing real-time software, provided for both technical and non-technical participants [INTV11, 13 and 15]. Three possible tools were suggested to be applied for design development and in any VM exercise; Autodesk Revit, BIM, and AutoCAD [INTV13 and 15]. These responses highlight the need of proper information distribution such that seminar participants could be fully informed during the seminar process to generate better solutions for the issues being discussed.

Table 4.31
DVM33 Visualization - Real Time Information

First order concepts		Representative Quotations
Real-time information	1.1	Decisions for design change and many other issues related to construction project can be made all the time. We can assist people rethink about the design and probably reconsider it. [INTV02]
	1.2	I think participants need a comprehensive presentation for better understanding of the situation. Sometimes I see them confused by the presented information due to complexity and the way it is presented. I believe it is not just the consultant technical background that is important, but other simple and important information, especially for non-technical people to understand, has its own significance. [INTV03]
	1.5	We will be given the information of the designed space during the seminar and the question to be solved is giving necessary suggestions to lower the cost and assisting to improve the design. [INTV07]
	1.6	We sometimes face conflicts between design documents provided in the seminar. It is time consuming when we cannot solve them and have to adjourn the seminar to next session. [INTV09]
	1.7	It would be much better if design changes were made in real time and all of seminar participants could contribute in design changing. [INTV10]
	1.8	A software capable of projecting the design of the considered project in the seminar could help us to visualize the design and to grasp the stream of the discussion. [INTV11]
	1.9	I prefer to visualize the design through CAD or REVIT in this seminar. I could understand more. [INTV13]
	1.10	I would rather reckon on BIM instead of hard printed drawings. [INTV15]

Table 4.31, continued

	1.11	Communicating the issue via mind mapping could be more efficient than FAST diagram. [INTV16]
	1.12	The facilitator employs fish bone diagram to help us identify the problems. [INTV20]
	1.13	We spend heaps of time to conceive the design. A 3D walkthrough could facilitate it. [INTV25]

This analysis shows that boundary of visualization is beyond depiction of overall three-dimensional design schemes. New technological advancements have incorporated many aspects of design such as equipment access, work accomplished and problem areas and construction sequencing (Alshawi et al., 1999). A key observation regarding visualization was profiting from application of Building Information Modeling [BIM]. This area is a future development on which research can be undertaken.

Basically, adoption of various approaches to bring information technology [IT] into the picture was looked as a proper way forward and was considered as an innovation by participants. It was stated that particular use of software to visualize design and other associated project information could result in saving participants' time given to grasp design information due the fact that a short period of time is generally allocated across seminar.

4.3.5.3 DVM07 Seminar information

This theme focuses on the timing, forms, sufficiency and sources of information utilized during VM seminar. Four first order concepts are included in this theme namely 'information updates', 'recommendation support', 'multiple sources' and 'information distribution' as shown in Table (4.32). A case regarding distribution of outdated information during seminar was observed where subsequent changes made to update the information were not effective [INTV05]. This emphasizes the required information to support seminar recommendations. INTV02 cited the attempt in search of additional information which could be used during seminar while it was aimed at counter checking consultants' recommendations. This indicates low confidence in the client's decision making. INTV17, 19 and 21 mentioned several instances where in respondents' view, consultants came to seminar without preparation and subsequently inadequate time was given to distribute and study the information [INTV23, 24 and 25].

Table 4.32
DVM 07 Seminar Information

First order concepts		Representative Quotations
Multiple source	1.1	I think working along with a data base as the basis in VM seminar could be very efficient as we see insufficient recommendations of consultants. Contribution of consultants is not convincing. In order to establish a data base, research has to be carried out by department within the market. [INTV02]
Information updates	1.2	There is so much information available here. [INTV05]
Recommendation support	1.3	It is necessary to support proposed changes with convincing documents. Since changes are supposed to tackle future issues of construction, it is obvious that to avoid further problems during construction such study is crucial although not applicable in a short period of time during VM seminar. [INTV16]
	1.4	We had VM meeting with the consultant and no conclusion such as design information or alternative to the solution was produced. The required system was not fully understood. [INTV17]
	1.5	Due to the complexity of the information and inefficient way of presentation participants are confused. Instead, a comprehensive presentation could provide the understanding of the issue. [INTV19]
Information distribution	1.6	The time given to participants to figure out the situation is not enough. I don't have the opportunity to go through details, maybe just quick skimming down the information. [INTV23]
	1.7	I could have fully studied the information and prepared myself if the information had been distributed earlier. [INTV24]

This analysis concludes that two contexts can summarize information attribute in design planning. The first context is the appropriate planning, preparation and management of client. The second context is creating client's desire for in-house consultants and preparation of supporting information.

4.3.5.4 DVM08 Decision making

Decision making can get improved through better communication among seminar participants. Therefore, this theme is built upon communication. According to interviewees' opinion, various views existed regarding decision-making during VM seminar (Table 4.33). Interviewees' responses mostly focused on the quality of information presented in the VM outcome by which future construction phase and related issues originated from the decisions made in the VM seminar can be supported [INTV15, 17 and 22]. Another interviewee underlined the liability for the recommendations and suggested existence of a sense of shared responsibility in decision making during the seminar [INTV15]. Another weakness of VM reporting system, recognized by an interviewee was lack of reporting information within VM report itself [INTV02]. This rooted in the necessity for the construction team encountering difficulties in tracing decisions made during VM seminar, when reverting back to the original design was required.

Table 4.33
DVM08 Decision-Making

First order concepts		Representative Quotations
Building communication	1.1	Despite no direct influence on the current VM study, representatives' contribution can create a strong basis of relationship and communication between other attending professionals and Legal Unit representatives. [INTV02]
	1.2	I think participants need a comprehensive presentation for better understanding of the situation. Sometimes I see them confused by the presented information due to complexity and the way it is presented. I believe it is not just the consultant technical background that is important, but other simple and important information, especially for non-technical people to understand, has its own significance. [INTV10]
	1.3	We study the ideas in VM and evaluate them, therefore in case of rejection of a proposed idea the reason behind it is clear and the proposer will not prejudge. [INTV17]
	1.4	Diversity of views in the seminar leads to looking into the issues from multiple angles. [INTV20]
	1.5	The result of the discussion was decisions and consensus rather than an efficient technique or a hard-technical tool. [INTV17]

Table 4.33, continued

	1.6	I think the necessary details and information have to be reflected by the report if the resultant recommendation of the seminar is attached to the contract. [INTV22]
	1.7	To grasp the constructability issues, we should have reverted to the original design before VM seminar so that we wouldn't investigate reasons during VM seminar. We see no solid justification for such move. [INTV02]

Generally speaking, a structured decision-making approach is what VM was built upon. Structured decision making increases the value of the project functions. There are several factors that play key roles in decision making among which completeness of information is one and the rest are visualization, distribution, culture and creativity. According to S. D. Green (1994), establishing a common decision framework to provide proper space for design team for better thinking and communicating is the main concern of the VM with no pretence at finding optimal answers. As S. D. Green and Liu (2007) said, VM is a team-based oriented approach and consequently creating a shared perceived reality is an important driving element.

4.3.5.5 DVM10 Systems Thinking

Since interviewees made reference on the need of proper interaction between the issues discussed during the seminar rather on other specific issues, this theme refers to evaluation of diverse complex issues that originate in the design of project (Table 4.34). INTV21 reported that real duration of construction was not reflected in a recommendation made during a seminar as would result in practice. Despite a requirement cited by INTV10 concerning establishment of a proper direction to guide and lead the entire process during the seminar, active participation of participants who were eager to put issue on debate resulted in positive feedbacks [INTV05 and 08].

Table 4.34
DVM10 System Thinking

First order concepts		Representative Quotations
System thinking	1.1	Developed ideas cannot get connected together through parallel workgroup system in VM. Separate workgroups create gap. [INTV18]
	1.2	There is an active interaction in the discussion among attendances [INTV05 and 08], but no clear direction exists to clarify the issues. [INTV10]
	1.3	We try our best to obtain the seminar objective for our client, but the long-term effects of the decisions made in this study have to be considered at the back end (i.e. construction phase). [INTV15]
	1.4	Issues like construction duration and supply chain of such recommended ideas are not raised in the discussion. They just decide from cost/benefit point of view. [INTV21]

Analysis shows that system thinking in VM is very encouraging for client, facilitator and participants and persuades them to see problems in a wider context. Deign planning activities defines all the connections, influences and integrations that exist amongst design components and sub-components. This supports the necessity of a VM study instead of simply engaging for a cost cutting exercise. In an organization, seeking value improvements should be considered as the footstone for system thinking rather than relying on cost saving issues in a project. The system thinking itself should be applied as the driving force for application of VM study while setting a financial threshold clause to grant a VM study only results in adding traditional value engineering exercise rather than a VM study.

The constant comparative analysis methodology was used to generate all 55 themes out of which only ten themes were selected as the top ones based on relationships that address objectives and research questions of this research. These top ten themes were analyzed and tabulated. Several positive attributes of team participation in VM seminar as well as limitations were observed. Limitations were found to impact design planning in terms of constructability, visualization, seminar information, systems thinking and participant's creative thinking processes and were believed to be responsible for slowing down the pace and efficiency of seminar en route to obtain better results for following design and construction stages of projects.

This research was based on the VM application in design process through multi-disciplinary involvement and has summarized ten attributes which govern the organizer's facilitation style, interaction, planning, paradigm, techniques and tools and control over the design process in a VM seminar. Furthermore, according to the analysis generation of these attributes led to detection of certain inter-related attributes and dependencies by which a guidance framework for future VM was formed. The created framework from this process is depicted in Figure 4.16.

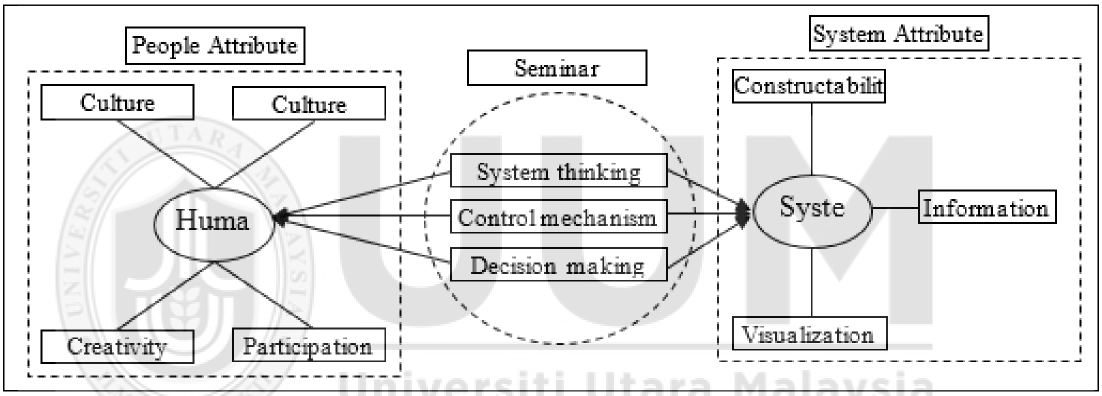

Figure 4.16
Formation of interview framework

The two major factors required in communicating VM outcomes, from the planning to construction phase of a project, are high-order thinking and strategic planning. Therefore, application of VM in the design process paves the way for changing demands and flexibility of design to support the construction process on site. This research has uncovered ten attributes with strong dependencies on each other and with influences on VM system. Accordingly, system and human aspects are the two major factors of VM that are covered by these attributes and they are highly dependent on the other. A supporting framework for future VM seminar organizers has been designed with respect to the design process covering all of the respective multi-dimensional elements that can influence the VM process.

CHAPTER FIVE

CASE STUDIES

5.1 Introduction

The context of the case study is well described in the client's brief and the architect's proposal. The background to the VM exercise is that following the cost estimates prepared by the quantity surveyor anticipates a considerable overspend if the project proceeds as planned. The value management exercise has been requested with the primary aim of reducing the overall cost without impacting the quality aspects of the client's requirements.

The case studies presented here have been considered in three different ways. First, since the sketch design has been prepared, a value engineering approach will be taken. This approach preserves the design as presented and looks to element functions to drive the search for innovative solutions that will provide the function at the required quality and the lowest cost. Immediately following this elemental approach is an illustration of a study to discover the primary reason for the element being configured as drawn and therefore its primary functions. It should be recognized that backward seeking in this manner may result in radical changes to the design. The final illustration is of a study that follows the logic of the project from prebriefed through briefing to sketch design. The study demonstrates a number of the techniques described in the former chapter. It is recognized that to undertake a value management study at the completion of a sketch design will result in abortive design work. This may still, however, offer the client the best value for money solution.

5.2 Case Study 1: Three-Story Reinforced Concrete Frame

5.2.1 Project Description

The project is located at the Serdang Perdana in the Selangor province. The project comprises of 20 units shop lot with RC frame in three levels. The total built-up area is 129,329 square meters. The elevation of the units is shown in Figure 5.1.

Figure 5.1
Units shop lot, Serdang Perdana, Selangor

5.2.2 System Aspect for Value Management

Based on the feedback received, the first solution-step is the determination of the structural form of the building from the spaces defined in the architectural drawings. Next, structural calculations lead to designs for determination of member sizes and steel reinforcement in the reinforced concrete structure. The objective of these structural designs is cost minimization through minimizing member sizes and steel reinforcement in the reinforced concrete structure.

The use of computers in carrying out the structural calculations referred to above leads to a situation in which a large number of alternative options can be considered for the structural form of the building. However, optimization studies for elastic design of structures have shown that approximate formulation of the design problem is necessary for its solution (Reinschmidt 1971). Simplification removes insignificant factors and renders the problem more manageable; it also leads to a reduction in the computational effort required for obtaining solutions. Making approximations in an optimization procedure does not invalidate the procedure, as the alternative of a search through every possible solution may not yield any significant differences where the objective is cost minimization in a building project.

The characterization of the optimal building project has as its objective the minimization of the combination of initial project costs, life-cycle costs, and costs associated with the time for completion of the project such that all the factors that determine the building project as enumerated above are considered and conflicting needs arising from the factors are satisfied. The optimization of any building project can readily be seen to be complex. However, design is an iterative process, and there are techniques or methods of optimal design which assist the identification of significant elements of the design in the search for an overall optimum.

5.2.3 Summary of VM Outcome from Case Study 1

The following data was achieved from the contract documentation for the project and is presented in tabular form for ease of evaluation. Table 5.1 presents the summary of recommendations of ZAN Company and includes the predicted savings cost which covers substructure, frame, floors and staircase elements. Based on value engineering analysis, it can be concluded that a total value engineering in the cost savings was RM 739948.68. Therefore, the outcome of VM study represented a 31.20% of potential savings on cost and provided an approximate net cost savings in accordance with Figure 5.2.

Table 5.1
Summary of award value and potential savings for Case study 1

				NG & NG CONSULT				ZNA			
				CORNER		INTERMEDIATE		CORNER		INTERMEDIATE	
ITEM	DESCRIPTION	UNIT	RATE	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM
	ELEMENT NO. 1 - SUBSTRUCTURE (Cont'd)										
	Ground beam										
A	25mm Diameter	kg	3.00	368	1,104.00	325	975.00	-	-	-	-
B	20mm Diameter	kg	3.00	156	468.00	138	414.00	-	-	-	-
C	16mm Diameter	kg	3.00	110	330.00	96	288.00	-	-	-	-
D	12mm Diameter	kg	3.00	187	561.00	165	495.00	-	-	-	-
	Strip Footing										
E	12mm Diameter	kg	3.00	-	-	-	-	727	2,181.00	644	1,932.00
	Layer of steel fabric reinforcement in ground floor slab as described :-										
F	A6	ms	8.70	-	-	-	-	176	1,531.20	139	1,209.30
G	A7	ms	11.00	321	3,531.00	250	2,750.00	-	-	-	-
	Formwork as described to :-										
H	Sides of pile cap	ms	33.00	30	990.00	22	726.00	-	-	-	-
J	Sides of column stump	ms	33.00	12	396.00	8	264.00	-	-	-	-
K	Sides of ground beam	ms	33.00	100	3,300.00	88	2,904.00	-	-	-	-
L	Sides of strip footing	ms	33.00	-	-	-	-	113	3,729.00	80	2,640.00
M	To edge of concrete exceeding 100mm but not exceeding 200mm high	m	9.00	36	324.00	14	126.00	36	324.00	14	126.00
	To Collection				11,004.00		8,942.00		7,765.20		5,907.30
	Collection										
	Substructure Page No. 1				26,390.75		20,869.50		16,269.50		13,662.00
	Substructure Page No. 2				11,004.00		8,942.00		7,765.20		5,907.30
	ELEMENT NO. 2 - SUBSTRUCTURE TOTAL CARRIED TO SUMMARY				37,394.75		29,811.50		24,034.70		19,569.30

Table 5.1, continoued

				NG & NG CONSULT				ZNA			
				CORNER		INTERMEDIATE		CORNER		INTERMEDIATE	
ITEM	DESCRIPTION	UNIT	RATE	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM
	ELEMENT NO. 4 - UPPER FLOOR										
	Vibrated reinforced concrete Grade 25 in:-										
C	100mm Thick suspended slab	ms	27.30	-	-	-	-	107	2,921.10	68	1,856.40
C	110mm Thick suspended slab	ms	30.03	-	-	-	-	111	3,333.33	44	1,321.32
A	125mm Thick suspended slab	ms	34.12	99	3,377.88	63	2,149.56	23	784.76	46	1,569.52
A	135mm Thick suspended slab	ms	36.85	-	-	-	-	22	810.70	42	1,547.70
B	150mm Thick suspended slab	ms	40.95	144	5,896.80	122	4,995.90	-	-	-	-
	Steel fabric reinforcement as described in:-										
	Suspended Floor Slab										
D	BRC A6	ms	8.70	-	-	-	-	402	3,497.40	233	2,027.10
D	BRC A7	ms	11.00	273	3,003.00	156	1,716.00	176	1,936.00	181	1,991.00
E	BRC B6	ms	12.75	107	1,364.25	10	127.50	-	-	-	-
E	BRC B7	ms	15.00	164	2,460.00	250	3,750.00	-	-	-	-
	Formwork as described to :-										
H	Soffit of suspended floor slab	ms	33.00	243	8,019.00	185	6,105.00	263	8,679.00	200	6,600.00
	ELEMENT NO. 4 - UPPER FLOOR TOTAL CARRIED TO SUMMARY				24,120.93		18,843.96		21,962.29		16,913.04

Table 5.1, continoued

				NG & NG CONSULT				ZNA			
				CORNER		INTERMEDIATE		CORNER		INTERMEDIATE	
ITEM	DESCRIPTION	UNIT	RATE	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM
	ELEMENT NO. 5 - ROOF										
	Vibrated reinforced concrete Grade 25 in :-										
A	Roof beam	mc	273.00	14	3,822.00	9	2,457.00	7	1,911.00	4	1,092.00
	Mild steel rod reinforcement as described in :-										
	Roof beam										
B	10mm Diameter	kg	3.00	338	1,014.00	216	648.00	-	-	-	-
C	6mm Diameter	kg	3.00	13	39.00	7	21.00	152	456.00	87	261.00
	High tensile steel rod reinforcement as described in :-										
	Roof beam										
D	25mm Diameter	kg	3.00	1,044	3,132.00	668	2,004.00	214	642.00	122	366.00
E	20mm Diameter	kg	3.00	172	516.00	110	330.00	104	312.00	59	177.00
F	16mm Diameter	kg	3.00	137	411.00	87	261.00	391	1,173.00	296	888.00
G	12mm Diameter	kg	3.00	293	879.00	187	561.00	76	228.00	43	129.00
H	10mm Diameter	kg	3.00	-	-	-	-	151	453.00	86	258.00
	Formwork as described to :-										
J	Sides and soffit of roof beam	ms	33.00	146	4,818.00	112	3,696.00	123	4,059.00	70	2,310.00
	Vibrated reinforced concrete 'Grade 25' mixed with waterproofing admixtures as described:-										
K	100mm Thick roof slab	ms	27.30	28	764.40	22	600.60	28	764.40	22	600.60
	Steel fabric reinforcement as described in:-										
	Roof slab										
L	BRC A7	ms	11.00	32	352.00	25	275.00				
M	BRC A6	ms	8.70					32	278.40	25	217.50
	Formwork as described:-										
N	Soffit of suspended roof slab	ms	33.00	21	693.00	20	660.00	25	825.00	24	792.00
	ELEMENT NO. 5 - ROOF TOTAL CARRIED TO SUMMARY				16,440.40		11,513.60		11,101.80		7,091.10

Table 5.1, continoued

				NG & NG CONSULT				ZNA			
				CORNER		INTERMEDIATE		CORNER		INTERMEDIATE	
ITEM	DESCRIPTION	UNIT	RATE	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM
	ELEMENT NO. 6 - STAIRCASE										
	STAIRCASE STRUCTURE										
	Vibrated reinforced concrete 'Grade 25' as described including reinforcement, formwork and finishes and all related works:-										
A	Staircases	mc	273.00	10	2,730.00	10	2,730.00	9	2,457.00	9	2,457.00
B	175mm thick landing slab	ms	47.77	23	1,098.71	23	1,098.71	19	907.63	19	907.63
C	Landing beam	mc	273.00	2	546.00	2	546.00	1	273.00	1	273.00
	Mild steel rod reinforcement as described in :-										
	Landing Beam										
D	6mm diameter	kg	3.00	21	63.00	21	63.00	9	27.00	9	27.00
	High tensile steel rod reinforcement as described in :-										
	Staircase and landing slab										
E	10mm diameter	kg	3.00	146	438.00	146	438.00	373	1,119.00	373	1,119.00
F	12mm diameter	kg	3.00	-	-	-	-	19	57.00	19	57.00
G	16mm diameter	kg	3.00	1,643	4,929.00	1,643	4,929.00	500	1,500.00	500	1,500.00
	Landing beam										
H	10mm diameter	kg	3.00	-	-	-	-	47	141.00	47	141.00
J	12mm diameter	kg	3.00	12	36.00	12	36.00	23	69.00	23	69.00
K	16mm diameter	kg	3.00	71	213.00	71	213.00	37	111.00	37	111.00
	Formwork as described to:-										
L	Sloping soffit of staircase	ms	33.00	38	1,254.00	38	1,254.00	32	1,056.00	32	1,056.00
M	Soffit of landing slab	ms	33.00	23	759.00	23	759.00	19	627.00	19	627.00
N	Sides and soffit of landing beam	ms	33.00	24	792.00	24	792.00	15	495.00	15	495.00
P	Edges of undercut risers execeeding 200mm but not execeeding 300mm high	m	9.00	128	1,152.00	128	1,152.00	128	1,152.00	128	1,152.00
Q	To raking open string of staircase 300mm (extreme)	m	18.00	96	1,728.00	96	1,728.00	96	1,728.00	96	1,728.00
	ELEMENT NO. 6 - STAIRCASES TOTAL CARRIED TO SUMMARY				15,738.71		15,738.71		11,719.63		11,719.63

Table 5.1, continoued

				NG & NG CONSULT				ZNA			
				CORNER		INTERMEDIATE		CORNER		INTERMEDIATE	
ITEM	DESCRIPTION	UNIT	RATE	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM	QUANTITY	RM
	<u>SUMMARY</u>										
	ELEMENT NO. 1 - PILING				Shown Separately						
	ELEMENT NO. 2 - SUBSTRUCTURE				37,394.75		29,811.50		24,034.70		19,569.30
	ELEMENT NO. 3 - FRAME				59,622.00		33,990.00		34,122.00		20,952.00
	ELEMENT NO. 4 - UPPER FLOOR				24,120.93		18,843.96		21,962.29		16,913.04
	ELEMENT NO. 5 - ROOF				16,440.40		11,513.60		11,101.80		7,091.10
	ELEMENT NO. 6 - STAIRCASE				15,738.71		15,738.71		11,719.63		11,719.63
	<u>TOTAL</u>				153,316.79		109,897.77		102,940.42		76,245.07
	Quantity of Unit				x 4 units		x 16 units		x 4 units		x 16 units
	Total Amount for each type Corner & Intermediate				613,267.16		1,758,364.32		411,761.68		1,219,921.12
	Total Amount for all type Corner & Intermediate				2,371,631.48				1,631,682.80		
	Cost Savings Amount (RM)				739,948.68						
	Cost Savings Percentage (%)				31.20%						

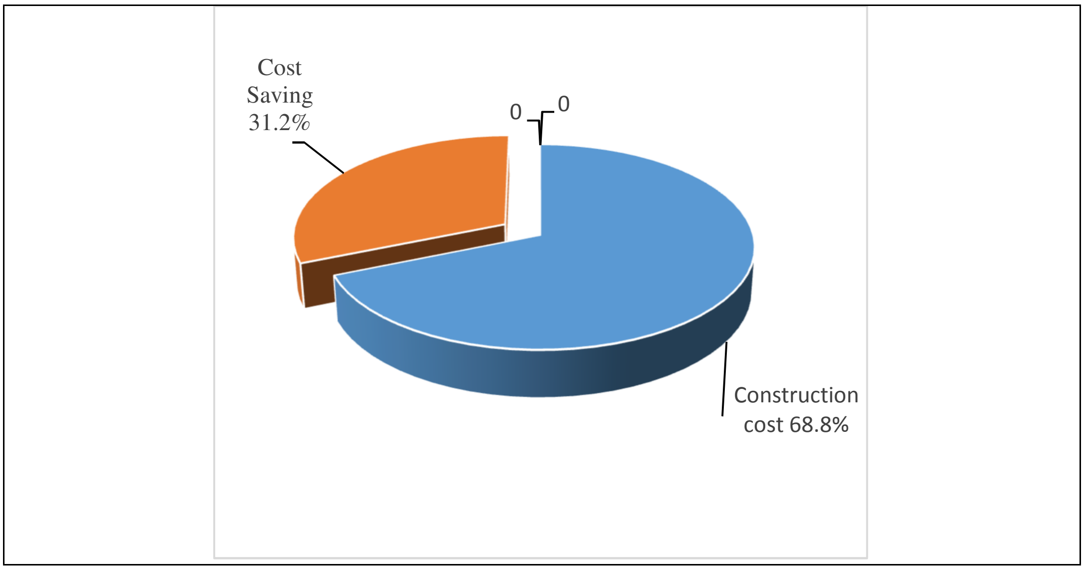

Figure 5.2
VM Predicted Potential Savings, Case Study 1

Based on above discussion and variations derived from Case Study 1, it was indicated that there was an additional cost and time impact on this project. Variations occur during the construction stage resulting in lack of the optimal design for determination of structural-element sizes and steel reinforcement in the building structure. The purpose of this structural design is cost minimization through minimizing element sizes and steel reinforcement in the structure as presented in Table 5.1 of the award value of the project by using the ZNA's process. As an important means of scheme optimization, VM did not receive a valid application in the field of projects investment control in Malaysia. The reason lies mainly in the following areas:

(i) Lack of professionals which master the knowledge of VM.

When using VM, professionals should not only master the method of VM, but also understand construction technology and investment management however, the widespread phenomenon is that engineers do not know the contents of investment management, and investment managers know little about the technical knowledge of construction.

(ii) Lack of a special link or mechanism which optimizes the design scheme by VM.

VM is a process which combines technical scheme and economic evaluation. Under the current management of project design, technical scheme and economic evaluation are completed by different departments. Technical and economic professionals work relatively independent, lack of a mechanism which completes the design work jointly.

(iii) Lack a system which insures the use of VM at the design stage

At present, there is lack of the special content which uses VM to review design scheme at design phase. There isn't a corresponding service fee rules and reward system for the use of VM to optimize design scheme. As a result, design units have no interest in optimize design scheme and improve investment benefit by using VM.

5.3 Case Study 2: Ten-Story Reinforced Concrete Frame

5.3.1.1 Project description

The three-residence building at the Daerah Gombak, Selangor, conducted by Perunding ZNA was used as the case study 2. The building was used to investigate the effectiveness of VM method in optimizing the design of building components and cost. The project comprises three identical ten-story apartment blocks with a total of 488 home units. The apartment's homes have a built-up area of 850 sq ft each. Each unit comes with three bedrooms and two parking bays. The elevation of black A is shown in Figure 5.3.

Figure 5.3
Block A of the buildings, Daerah Gombak, Selangor

This case study was chosen among the succeeded projects which fall short to meet the project objective (i.e. cost) without applying VM process used by Perunding ZNA. The intention is to discuss issues such as involvement and contribution of various professionals, the overall application and practices of VM in the construction sectors, savings obtained along with attempting to comply with client's objectives with respect to cost optimization, strategic stage effect. The focus of this study is on cost optimization opportunities (i.e. the detailed design stage) and value-adding ambitions of designer.

5.3.2 Value design analysis

The literature highlights existence of a weakness within design and building systems and this is especially related to coordination during the design stage where early involvement of the contractor is expected to cause more effective achievement of project objectives. Therefore, application of VM including contractors' inputs during design stage helps addressing issues linked with cost optimization and value adding to client's demands. Hence, by applying the VM this research is in quest of the following main purposes:

i) To identify the process of decision-making carried out during design stage by the design team and contractors;

ii) To identify limitations encountered by contractors and design teams in providing design which fully meet client's demand;

iii) To evaluate the improved level of buildability during construction as the result of application of VM during the design stage with regard to the contractor perceptions;

iv) To investigate the potential savings resulted by VM intervention during the design stage, specifically under consideration of contractors' inputs.

5.3.3 Presentation of cost data for Case Study 2

The summary of detail cost variations related to Case Study 2 that occurred during design optimization process are indicated in Table 5.2. Based on VM analysis, it is concluded that a total potential VM savings in the initial cost was RM 1520762 for each block. The findings are summarized in Table 5.2. The savings were achieved on the basis of ideas from the procedure which was suggested by Perunding ZNA. The extensive details of the cost saving variations of each element for the case study are given in the following section. Based on value design analysis, it is deduced that the VM which was proposed by Perunding ZNA has the potential of cost saving in the initial cost of the project.

*T*able 5.2

Cost estimate based on revised drawing from Perunding ZNA

Item	Description	Unit	Quantity (For 1 block only)				Rate	Amount	Remark
			Original	Revised (based on ZNA drawing)	Difference	% of difference			
	Block A								
1	Piling works	m	7,069.0 (400 x 400mm RC pile, 516 point, 12m length)	4,644.0 (400 x 400mm RC pile, 339 point, 12m length)	2425.0	34.3%	172.00	(417,100.00)	Average actual penetration depth at 13.7m (up to-date)
	V.O works :							180,417.00	MLT test (390T) - Provisonal VO 1
	Sub-total (A) :							(236,700.00)	
2	Strip footing & grd beam								
	a. Concrete	m3	1,045 (Pile cap, stump, grd beam	605 (Strip footing & grd beam)	(440.00)	-42.1%	286.00	(125,840.00)	
	b. Formwork	m2	2,578	2,444	(134.00)	-5.2%	33.80	(4,529.20)	
	c. Reinforcement	kg	89,436	57,793	(31,643.00)	-35.4%	3.20	(101,257.60)	
3	Column (grd-10th)								
	a. Concrete	m3	302	238	(64.00)	-21.2%	286.00	(18,304.00)	
	b. Formwork	m2	3,900	2,243	(1,657.00)	-42.5%	33.80	(56,006.60)	
	c. Reinforcement	kg	51,925	31,800	(20,125.00)	-38.8%	3.20	(64,400.00)	
4	Upper floor beam (1st-10th)								
	a. Concrete	m3	1,402	1,176	(226.00)	-16.1%	286.00	(64,636.00)	
	b. Formwork	m2	16,944	16,195	(749.00)	-4.4%	33.80	(25,316.20)	
	c. Reinforcement	kg	381,836	221,718	(160,118.00)	-41.9%	3.20	(512,377.60)	
5	Slab (grd- 10th)								
	a. Concrete	m3	2,659	2,538	(121.00)	-4.6%	286.00	(34,606.00)	Original - Ground floor 125mm thk with BRC B6,7,8 & A7 (T&B)
	b. Formwork	m2	19,345	22,022	2,677.00	13.8%	33.80	90,482.60	- Typical floor 110mm thk with BRC A7 & A8 (T&B)
	c. Reinforcement	kg	16,284	-	(16,284.00)	-100.0%	3.20	(52,108.80)	
	e. Ditto (BRC A7)	m2	44,450	29,575	(14,875.00)	-33.5%	13.00	(193,375.00)	VE - Ground flr 110mm thk with 1 layer BRC A7
	f. Ditto (BRC B6)	m2	5,657	-	(5,657.00)	-100.0%	15.50	(87,683.50)	- Typical floor 100mm thk with 1 layer BRC A7
	g. Ditto (BRC B7)	m2	645	-	(645.00)	-100.0%	18.40	(11,868.00)	Original BRC Area (50,752m2)
									Revised BRC Area (29,575m2) *(Reduce by 21,177m2 @41.7%)*
6	Lift wall & Shear wall (Grd to roof)								
	a. Concrete	m3	1,470	1,516	46.25	3.2%	286.00	13,227.50	Original - Lift wall & shear wall using rebar
	b. Formwork	m2	19,095.0	18,586	(509.00)	-2.7%	33.80	(17,204.20)	VE - Lift wall & shear wall using BRC & rebar
	c. Reinforcement	kg	174,362.0	5,847	(168,515.00)	-96.7%	3.20	(539,248.00)	
	d. Reinforcement (BRC A6)	m2	-	6,148.0	6,148.00	100.0%	10.20	62,709.60	
	e. Ditto (BRC A7)	m2	-	960.0	960.00	100.0%	13.00	12,480.00	
	f. Ditto (BRC B6)	m2	-	3,643.0	3,643.00	100.0%	15.50	56,466.50	
	g. Ditto (BRC B7)	m2	-	2,992.0	2,992.00	100.0%	18.40	55,052.80	
	Total for concrete (m3)	m3	6,877.8	6,073.0	(804.75)	-11.7%	286.00	(230,158.50)	
	Total for formwork (m2)	m2	61,862.0	61,490.0	(372.00)	-0.6%	33.80	(12,573.60)	
	Total for rebar (kg)	kg	713,843.0	317,158.0	(396,685.00)	-55.6%	3.20	(1,269,392.00)	
	Total for BRC A6	m2	-	6,148.0	6,148.00	100.0%	10.20	62,709.60	
	Total for BRC A7	m2	44,450.0	30,535.0	(13,915.00)	-31.3%	13.00	(180,895.00)	
	Total for BRC B6	m2	5,657.0	3,643.0	(2,014.00)	-35.6%	15.50	(31,217.00)	
	Total for BRC B7	m2	645.0	2,992.0	2,347.00	363.9%	18.40	43,184.80	
	Sub-total (B) :							(1,618,300.00)	
6	Adjustment on architectural works (Brickwall & finishes. Etc)	LS						218,400.00	
								115,838.00	Add. 30mm thick plastering to wall - VO2
	Sub-total (C) :							334,238.00	
	Total (A+B+C) Piling, structural & Architectural cost for Block A only :							**(1,520,762.00)**	
	Total for 2 block (A&B) :							**(3,041,524.00)**	

5.3.4 *VM study at elemental level*

The VM study at elemental level is found so efficient as the essence of this type of study is to ascertain the function of the elements and to determine whether those functions can be provided in a more cost-effective manner without prejudice to time or quality. The following demonstrates a study that concentrates on element function.

5.3.4.1 Element function

The significant action to be undertaken in element function analysis is to analysis and to prepare a histogram of the elemental costs. In comparing these elemental costs to original project, i.e. that project of similar nature for which element costs have previously been obtained, it is possible to determine which elemental costs are significantly higher than their original project counterparts. In the considered case study these elements are indicated in Figure 5.4.

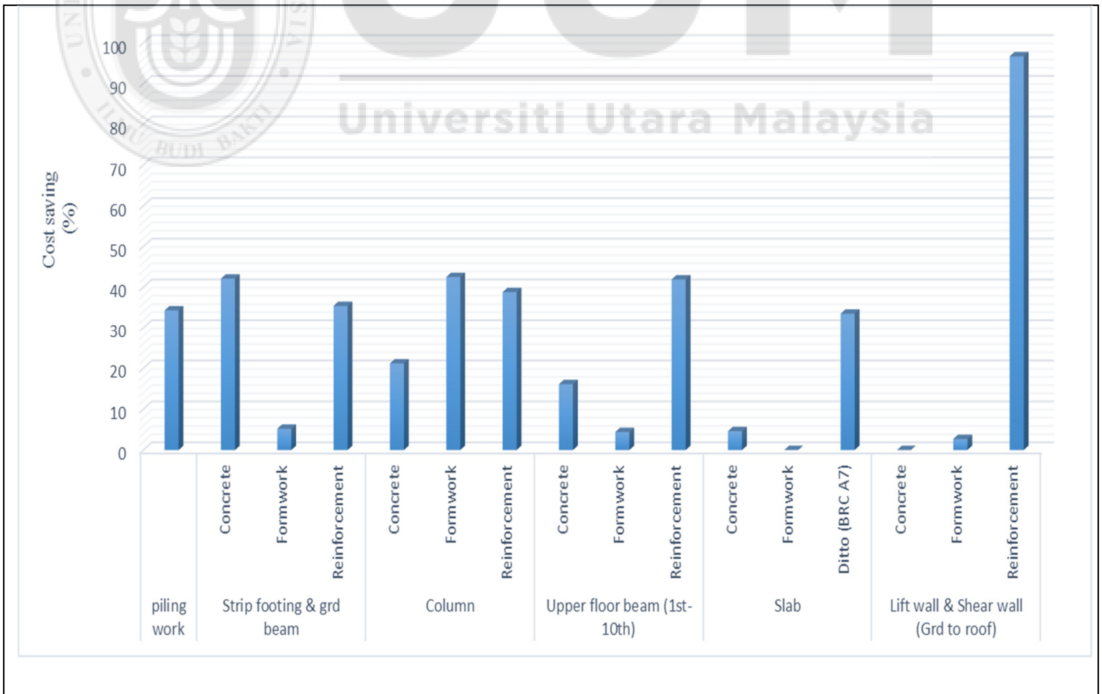

Figure 5.4
Element function analysis in Case Study 2

In the two case studies, many variations were observed. These variations subsequently resulted in increased costs which reduced or exceeded the savings achieved through VM. Base on the above outcomes, the analysis projects investment to a construction project at design stage by VM, and uses the results of the analysis to improve project design. From the theoretical analysis and project practice, the following conclusions obtained in this study:

• VM can help the project design scheme reach the best combination, and make the project investment structure more reasonable, and achieve the aim of control project investment.

• The object determination of value engineering should be consistent with the custom division of construction project to satisfy the functionality and cost analysis.

• It is necessity to set up a special link for VM at the review of design scheme, and to establish service fee rules and reward system for the use of VM.

5.4 Case Study 3: Damaged Foundation

5.4.1 Overview on Ground Condition

In this project, a foundation was built on a fill ground with varying depth of fill from 8m to 14m thick which consists of meta-sedimentary rocks of shale/sandstone inter layered with mudstone or schist as shown in Figure 5.5, (Neoh, 2008).

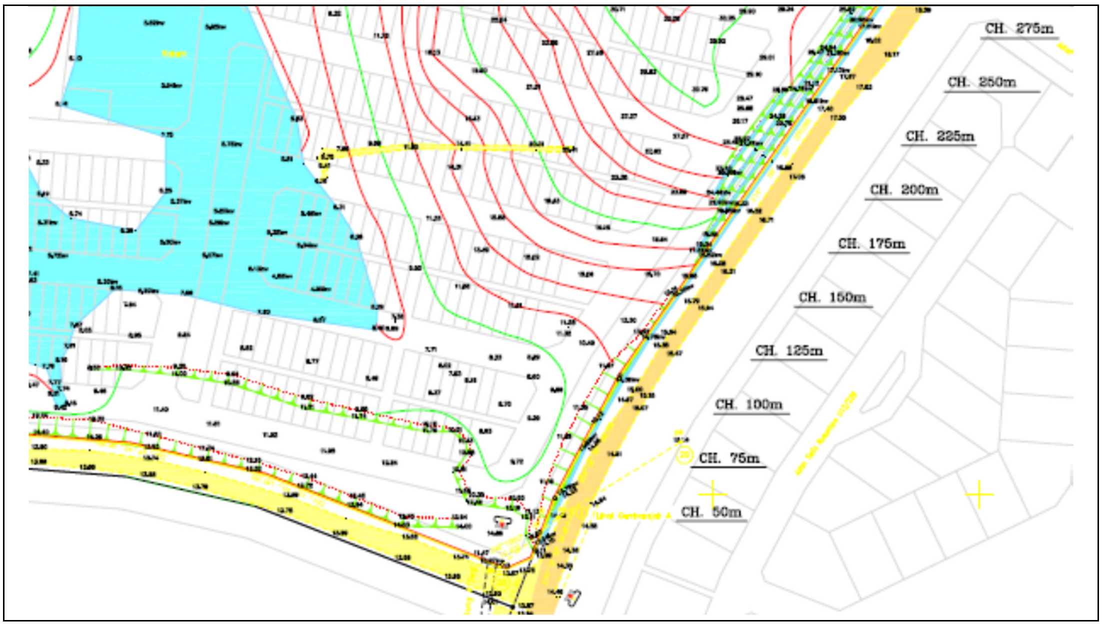

Figure 5.5
Topographical survey result of site location before the construction.

5.4.2 Original Foundation Design

The structural consultant proposed pile foundation to be adopted where 200mm square RC piles were designed as end bearing piles with capacity of 320kN. Piles were driven to proper set using 2.5-ton hydraulic hammer at 550mm drop with recorded penetration length of about 17m to 23m. The construction of pile caps and ground beams commenced upon acceptable and satisfactory results of pile tests such as Maintain Load Test (MLT), Pile Driving Analyser (PDA) and Pile Integrity Test (PIT). (Neoh, 2008).

5.4.3 Settlement Problem

In late 2007 when the ground floor structures were about 50% completed, ground settlement and cracks occurred at Block B, J, K, L and M (Figure 5.6). Furthermore, there were distorted and minor upheavals on ground slabs occurred due to differential settlement as shown in Figure 5.7 and 5.8. Further observation on Block J showed that some piles were cracked and the ground structures settled at least 200mm. Neoh (2008) reported additional pile tests of MLT and PDA and the results showed that some piles had failure load as low as 250kN as compared to design pile working load of 320kN. Based on the field test results and earthwork plan, it was found that more severely affected units were located at the areas where the original ground was lower than the rest and therefore water ponding had occurred during rainy season. It was also reported that 70% of borehole results showed strata at the interface between fill and very soft original ground with thickness varying from 2m to 5m and the top few meters from the original ground was quite dry but reported wet during rainy season (Neoh, 2008). From the bulk density tests, erratic results varied from 1.07 kN/m^3 to 2.68 kN/m^3 which indicated that many void spots or layers were near the interface between the fill and original ground level. Low field bulk density is usually at high moisture content with very low Standard Penetration Test (SPT) count ($N<4$) or at location where there were ponding during earth filling with the absence of dynamic sand filling. It is reported that the compaction of the fill was done by 10-ton roller only (Neoh, 2008). Based on the SI results on 26th June 2008, the six pit tests revealed that the water table was at least 3m below the existing ground level, although borehole water table was about 2m to 4m below ground level (bgl). Neoh (2008) also found that the fill material is mainly sandy clayey silt with some gravel with high silt content, varying from 16% to 81% with average value of 40%.

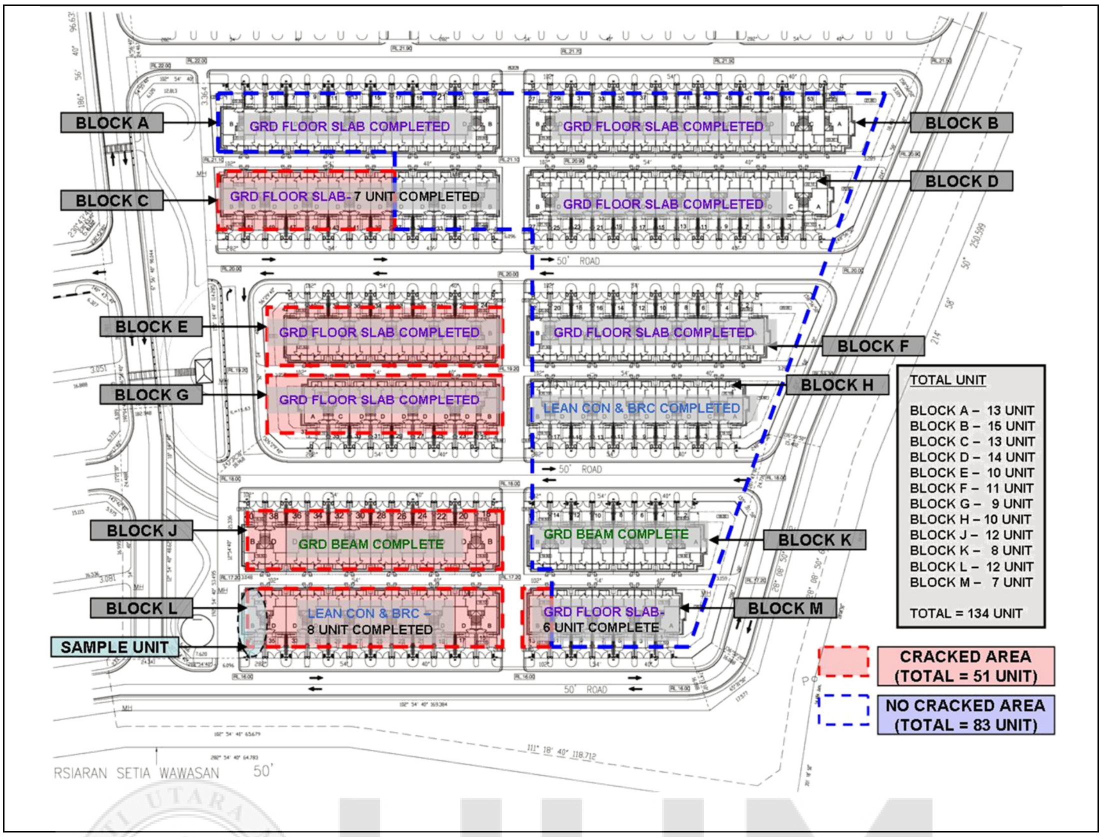

Figure 5.6
Location of the problematic structures.

Figure 5.7
Photo of distorted slab and major upheaval.

Figure 5.8
Excavation on the ground floor slab.

5.4.4 Findings

Based on geotechnical assessments carried out, the main possible causes for the observed ground cracks and piling problems (pile crack and low capacity) can be summarised as follows;

(a) More than 70% the borehole results clearly show that thickness of soft layers varied from 2m to 5m near the interface of filled and original ground level, where ponding and water log area were located. There is also a possibility that the original soft top soil was not adequately removed before carrying out the earthwork filling thus causing ground settlement. Collapse settlement also occurred under surcharge stress from the fill due to the soil composition which was wet and consisted of high silt content and high porosity.

(b) The collapse settlement of about 8m to 14m fill caused down drag vertical force and bending stress on piles supporting the ground beams, especially when the piles were not straight vertical (deflected by boulders).

(c) With the pile's negative friction fully mobilised, the induced down drag force with ultimate friction of at least 3kN caused piles to move a few millimetres to the maximum settlement of 10mm downwards or upwards as observed by settlement monitoring (Neoh, 2008).

5.4.5 Value Engineering Proposal

Prior to VM proposal, the Client had spent RM4,682,509 which can be considered as sunken cost as consulted a specialist Dr X from Company Y to propose a solution by which the estimated remedial work cost was approximately RM43,000 per house unit excluding the cost of demolition works for damaged structures. The proposed solution consists of under-pinning works with additional piles (24m penetration depth) with houses redesigned with fresh facade resulting in additional contract cost of RM 2.2 million.

The author through his VE consultant was then appointed for alternative design. Damaged structure was proposed to be removed, soil bearing was improved using Dynamic Compaction method (Figure 5.9) and ground floor slabs were designed as ground bearing non-suspended slab. An optimised strip foundation system was adopted on the improved ground through Dynamic Compaction method. The strip foundation is normally used when the subsoil layer is hard or mechanically improved through normal or dynamic compaction method.

Figure 5.9
Rolling dynamic compaction at the project site

Ground improvement process was comprised of stripping off the existing capping over the waste tip and compacted using the 8 tons non-circular or ‘square’ impact module towed by a 4-wheel tractor as shown in Figure 5.10 (Bouazza and Avalle, 2006). The vibration and noise due to this process can be a nuisance to people or cause damage to the surrounding structures. However, a field measurement is one of the ways to measure the magnitude of the vibration for risk assessment (Bouazza and Avalle, 2006).

Figure 5.10
Concept of Rolling Dynamic Compaction (Bouazza and Avalle,2006)

5.4.6 Cost Comparison

Contract Sum : $26,867,000.00

Cost of Piling : 1.6 Million or around $12,000.00 per unit

Total contract sum for this project is RM 26,867.00 based on original consultant's design using conventional method. With Author's VE proposal, total saving for foundation was RM 3,449,048.00 including saving of $8,085.35 per unit (structural segment only) for superstructure works. The cost saving for unit Type A only is summarised in Table 5.3. This VE exercise enabled original cost of contract to be retained including absorption of sunken cost of upgrade of these houses.

Table 5.3
Location Map of The Studied Projects

Item	Element	Conventional Design	VE Design	Remarks
A	Piling Work	16,925.23	-	
B	Demolition	-	453.60	
C	Ground Improvement	-	6,951.34	Dynamic Compaction
D	Work Below Lowest Floor Finish	21,639.30	14,158.30	
E	Frame	18,067.60	15,659.60	
F	Upper Floor	9,294.50	9,629.50	
G	Staircase	1,092.95	1,808.05	
	Total Cost	67,019.58	48,660.40	27.4%

CHAPTER SIX

CONCLUSION

6.1 Introduction

This research investigated the opportunity to improve the consulting engineer's role by introducing VM as an additional service for their clients. This was done through use of a survey, interviews and the case studies to discover the opinion, attitude and perspective of a representative sample of Malaysia construction team. This will enable consulting engineers, their clients and construction professionals in general to come up with a better understanding of the parameters and variables that impact the introduction and application of VM. According to the interviewees' responses from the survey, it was shown that majority of stakeholders have greatly accepted VM as an influential and effective approach to optimize the project cost, facilities and system. 25 interviews were conducted amongst the construction project teams who were involved in VM seminar as participants to provide further in-depth investigation to support the findings from the survey. The VM methodology on the practical case studies has proved its major substantial, positive impact. The contribution level of VM in construction projects and cost optimization during the design stage were the issues around which the importance of VM was considered and discussed. As a result, this research identified various attributes prevalent in the examined VM process and used the analyzed data and attributes to develop a framework that will guide future organizers of VM with the major focus on construction project at design stage.

6.2 Conclusions

6.3 Conclusion from survey and interview analysis

This research was initiated to examine aspects contributing/hindering multi-disciplinary involvement during VM seminar focused on the design planning of construction projects. According to the extant and recent literature, involvement of multi-disciplinary teams in VM seminar is indispensable and has been proven by numerous previous research studies. This research takes another step forward in looking at multi-disciplinary team involvement from both the human interaction and thinking process standpoints.

In attempt to fulfill the objectives, the interview questions were set and designed at the beginning of this research to guide the researcher in investigating the topic in greater depth. The following subsections will discuss findings made in terms of answering these four research interview questions, which were:

1. In a construction project how the process of design planning is performed through VM?

2. Which elements do affect decision-making process and human interaction of VM seminar participants?

3. How are the outcomes of the project design and planning affected by the multi-disciplinary participant involvement in a VM seminar?

4. How are the subsequent construction phases of a project impacted by these interactions and decision process through VM?

6.3.1 Research Question 1

The process of design planning involves multi-disciplinary stakeholder involvement that goes well beyond normal construction project team activities. The stakeholders involved comprise of technical and non-technical participants involved in addressing all the design requirements and construction planning needs for the project. VM seminars conducted for the case studies undertaken for this research were driven by the policy needs of the client (MAHB) that set the threshold value of projects, which necessitated VM studies to be undertaken. The VM process operated in the construction projects formed part of the Standard Operating Procedure [SOP] for every new project initiated, in order to gain approval from public and private financial sources. Each project needs to complete a VM study in order to increase value for the project while at the same retaining optimum development costs for the client. Thus, the completion of a VM study is part of the overall requirements for a project to be approved by the client top management to permit further development.

Across all cases observed, the conduct of the VM process adhered to the internal procedures issued by the client's organisation. The operation of such procedures complies with the National Guideline on VM conduct and is also consistent with international VM standards.

During the seminar, it was observed that there was a consistent application of similar tools and techniques across all cases. Functional analysis was used during the Information phase to identify the specific study problem(s) and ensure that seminar participants were at the same level of understanding on project issues. Presentation and brainstorming techniques were used to generate ideas and solutions to problems identified during the Information phase. It was observed that such approach was taken due to the complexity of the project package that consists of main terminal building design.

Methods, specifications, policies, approaches and statutory by-laws were used as the main seminar references.. Functional analysis, brainstorming, ideas evaluation and decision-making were made consistently in line with the VM methodology. Despite the appropriate methodology and approaches having been adhered to, the design planning issues studied in the case study depicted different paradigms and perspectives from the way seminar process and outcome produce. The design-planning phase in this VM seminar depicted a cost cutting exercise based on the conceptual design. This was apparent where all cases used drawings purely to find opportunities to reduce construction costs, instead of focusing on improving project delivery on-site.

Brainstorming was the main idea generation technique used across all cases. However, findings among seminar participants revealed that the technique itself lacked an appropriate structure to guide participants to be fully engaged in providing substantive contributions during seminar. This was particularly so when the project packages being considered involved many complex elements and interfaces that required specific guidance to assist with problem solving. The level of freedom applied in the brainstorming process was acknowledged by respondents, but the fact that there were no boundary limits to the process meant that seminar participants felt the need to rely solely on the facilitator's leadership instead of self-initialising their own contributions and ideas. Several factors were also observed to have influenced the use of the brainstorming technique in seminar, where 'cultural block' and 'institutionalised attachment' driven thinking remained relatively dominant throughout the process.

The VM outcomes were observed to have purely focused on achieving cost reduction along with design improvement that would better facilitate the construction process. Many of the responses from seminar participants indicates that relatively less attention was given to how each proposed design was going to be built but instead more weight was place on the percentage saving that could be generated. The conduct of seminar actually reflects and simulates an approach that normally focuses on conceptual design and involves the facilitator, client and design team. Despite the involvement of various stakeholders who could probably add value to the entire design planning process, the outcomes achieved by the seminar suggested the opposite.

Factors contributing to such observations are discussed in the following sub-section, which also includes some suggested improvement measures that could be practically implemented in future VM studies.

6.3.2 Research Question 2

Researchers in the VM field constantly reiterate that applying a structured approach to define project function is at the heart of the VM methodology. The structured approach relates to the style of seminar, tools and techniques to be applied that assist participants' creativity and decision-making processes during VM seminar. Throughout this research, several factors have been identified that have influence over the way that participants interact throughout the creative and decision making processes. Two major groups of factors were identified, which are 'human' and 'system' aspects of VM.

The human aspect comprises of four attributes - participation, culture, creativity and knowledge. Participation attributes were found to influence the role-playing position of seminar participants. A dilemma exists within the observed seminar environments as participants only contribute on areas of discussion that are within their discipline and professional responsibilities and roles and thus they remain disconnected from considering and developing proposals that affect or connect them with other professions. Such role-playing is observed to limit the level of participation among seminar participants, where they are concerned solely on issues and decisions within their own professional boundaries. Participation during the Speculation and Judgment phases also affect the participants lacking a non- technical background, where if substantial improvement was made to the way that seminar information is communicated, improvements could be wrought to their level of contribution during the VM seminar process.

The culture attribute of the seminar suggested a more dynamic form of interaction but culture blocks were observed in some of the cases where the "superior- subordinate" stigma still existed among a few seminar participants. This finding was highly related to those dominant participants who tend to take a lead across major discussion activities among seminar participants. Seminar participants were also observed to be making their contributions based on their institutional representation that only allows them to perceive issues from one perspective. This leads to different interpretations of seminar issues among VM participants. At the same time, the facilitator's leadership during the seminar process was highly regarded as a motivational factor that influenced seminar participants to be fully engaged during discussions and the problem solving processes. The facilitation styles were perceived to be a driving factor for reconciling participant dynamics during discussions.

The creativity attribute focuses on participants' involvement in applying techniques and based also on their professional working backgrounds. It was found that the application of the brainstorming technique provide an opportunity for participants to expand their thinking and provide a better contribution towards solving seminar issues. However, participants perceived that there was still room for improvement on the way of conducting the brainstorming technique. The technique itself was adopted due to its methodology that focuses on generating a large quantity of ideas. Despite this positive aspect, the application of brainstorming, particularly when related to a design planning project, due to the complexity and nature of such projects, may require this technique as currently applied to be altered. Respondents felt that the introduction of a structure which can better guide seminar participants to think in a more focused manner during the brainstorming process could have set a more acceptable boundary instead of a more free-wheel based session. For instance, in discussing issues on the design of the baggage handling system [BHS], the brainstorming process could be improved through the inclusion of a checklist that provide parameters on appropriate designs to support the effective operation of the BHS. Such a checklist could provide assistance to seminar participants to facilitate thinking to produce more relevant solutions to the issues. The professional working background was also noted to be influencing participants' creative thinking levels. The majority of respondents agree that the application of their own tacit knowledge during creative and decision-making processes assisted them throughout the seminar process.

The knowledge attribute relates to seminar participants' levels of understanding of the VM application and methodology. According to the literature, participants' ability to understand and comprehend functional analysis plays a significant role in attracting them to be highly engaged with seminar discussions. In the cases in this research, the majority of respondents were found to have a limited understanding of FA, which therefore led to them being non-responsive during the early seminar and greater participation only transpired with the facilitator's leadership. Participants perceived that following the facilitator's directions and appreciating the facilitation style in controlling the seminar process assisted them when they found FA to be too difficult to make sense of. In terms of their level of VM understanding, internal participants had no issues with the conduct of the VM seminar. This was due to existing policies offering continuous support in terms of providing training and courses on VM. On the other hand, the external participants were purely relying on their previous VM experience and the leadership of the facilitators to successfully get them through the seminar process. The level of knowledge and understanding of VM was observed to be a crucial factors that influences participants' creative and decision-making processes. This is due to the nature and complexity of projects under study that demanded a high level of engagement, which doesn't give sufficient time for a good VM learning experience. Therefore, experience and knowledge in VM is crucial to be present amongst potential seminar participants to ensure the smooth running of the seminar process.

The system aspect of VM comprises of information, visualisation and constructability attributes. These attributes influence seminar participants' involvement through the application of assisted tools, materials and documentation.

The information attributes is concerned with the timing of seminar information distributed to the seminar participants. It was observed that the distribution of seminar information during the Information phase of the seminar is perceived to influence participants' ability to comprehend information within a relatively short period of time. The Information phase was observed to run for between 1 to 1.45 hours and during this period, activities such as presentations, functional analysis, information studying and briefings were compressed into the period. This left little time for participants to become sufficiently familiar with the seminar information. It has to be noted that amongst the seminar participants were some project consultants that had been involved with the project from the beginning, therefore familiarity with information for them was not an issue. However, consideration should be given to the very different situation pertaining to the non-technical background participants who were only invited to join the discussions at a key point during design planning stage instead of having continuous involvement from the beginning.

The visualisation attribute significantly influences the way that participants view and communicate seminar issues. It goes beyond studying traditional physical drawings and understanding the documentation delivered as information during a VM seminar. The improvements suggested by seminar participants and validated via expert panel consideration were focused on a greater use and application of IT in VM seminars. This topic has been researched by several authors who investigated tools designed to assist decision-making and creativity processes. Findings from this research saw the generation by respondents of a wish list where application of software were perceived to potentially increase participants' understanding of the seminar discussions. This was due to the ability of such software to depict complex design and other information in a more intelligible form. This reduces the time for participants to be familiar with seminar information and allows for changes to be made in real-time. The introduction of visualisation software combined with the use of a more structured guide for applying the brainstorming technique, according to respondents, provides a great opportunity for the VM seminar to test out possible proposed solutions without compromising the time and quality of the eventual output.

Constructability attributes are concerned with developing a structured method to assist seminar participants to approach design planning in terms of finding solutions that correspond specifically to buildability matters. It has been observed that much of the focus across all seminars in this research uses creative and decision-making tools/technique to encourage participants to think, however, limited references in the literature were made to studying approaches that are designed purely to promote or improve the buildability of the proposed design. The inclusion and consideration of buildability parameters in VM seminars, as an addition to existing tools/techniques, could improve participants' engagement levels. This could be included during brainstorming sessions as previously discussed, where setting of parameters that assist participants thinking directions is perceived to impact significantly on the outcomes from the VM process. The way that participants engage in the creative thinking and decision making processes requires some form of structured and flexible approach that can help to improve VM outcomes related to subsequent construction impact.

It can be summarised that there are seven attributes that affect multi-disciplinary creative and decision-making process in a VM seminar. The relationship between all seven attributes is highly dependent upon each of them and through the research validation process, it is posited that consideration and integration of all of these attributes could improve participants' involvement during the VM process.

6.3.3 Research Question 3 and 4

Seminar participants work on mutually understanding shared objectives and improving the output of the VM study. This improvement can be implemented through considering factors that influence the level of participation among seminar participants as discussed in the previous sub-section. In terms of the VM seminar from the organiser's point of view, the implementation of VM should be conducted beyond just the paradigm of cost efficiency policies that place dollar values as the major outcome. The perspective needs to extend further by considering a systems thinking approach that views the seminar study as a whole system that can affect and impact on the design planning process. The systems thinking paradigm in VM is essential in considering the whole study from a much wider perspective. Eliminating the stereotypical perception of VM as purely a set of cost cutting tools should be the starting point for a new paradigm shift. The outcome of the VM study is highly dependant on the effectiveness of the seminar participants to be fully engaged in relevant discussions, undertake creative thinking process and generate success factors as suggested by Shen et al.

(2003). The ability to infuse system thinking at the outset of the VM process on the part of the organiser and seminar participants creates a different set of goals that will drive participants to make a better strategic contribution that can impact beneficially on the construction phase and operations as a whole.

Each construction project has a unique output as a result of varying degrees of complexity of different projects. The application of a standard VM methodology that applies to all forms of project packages is observed to have minimal impact on the outcomes and the solutions. This is where appropriate establishment and operation of a control mechanism for the seminar process on the part of the organiser plays a significant role in tailoring seminar proceedings according to the nature of the project. This control mechanism encompasses attributes that aim to govern the seminar process through a flexible application of tools, techniques, participants controls, interaction and appointments.

Finally, the outcome from VM seminar process is based on a collective team decision-making effort. Such outcomes require a unified understanding of seminar study problems and a concerted effort to propose possible solutions for improvement. VM seminar participants of construction projects are a real asset to the client and the decisions made during the seminar process become a benefit rather than a liability for the project. The influences of seminar participants that affect VM outcomes are not only confined within the seminar environment itself, but they extend to the post-seminar phases where accountability for the seminar recommendations is considered. Consideration of the accountability and liability for VM outcomes should be made transparent within the seminar environment, in order to ensure that any future ramifications during the construction phase can be more easily solved.

6.4 Conclusion from research objectives

This section addresses how, and to what extent, the research has met its objectives.

6.4.1 Research Objective 1

The main issue addressed in this dissertation was to develop a VM methodology through the use of a commination of finite element software and GA optimization techniques by introducing a fitness function to search for the optimal design of structural elements to minimize the cost value of construction projects. The proposed VM method used an optimization procedure to obtain the necessary functions with the minimum cost. It emphasizes through functional analysis and functional improvements to make the project design scheme reach the best combination at the technical and economic. This is the advantage that the other control methods do not possess. Therefore, there is great significance to analyze and adjust the matching degree of functions and cost among the various sub-project through the use of VM at the design stage. VM method was helped to form a good design scheme, make the project investment structure more reasonable, increase the utilization of funds, and control project investment effectively. To demonstrate the validity and efficiency of the proposed optimization algorithm, various case studies were conducted in Malaysia. Results indicated that the proposed VM algorithm could improve the building outcomes and support owners to control project investment actively at the design stage and to improve the utilization of funds effectively.

6.4.2 Research Objective 2 and 3

The results demonstrated that, the VM was identified as having the potential to deliver sustainability for projects owing to its utilisation of diverse knowledge resources, professional disciplines and stakeholders, facilitated environment, strategic timing and effective processes. VM ensures that sustainability is brought forefront before critical decisions are made. It could reduce the conflicting interest between cost and environmental and social issues. Commitment to sustainability can be secured through positive interaction between clients and VM facilitators and then positive participation between team members.

This research discovered the challenges that faced by the VM participants during the VM studies and provided increased awareness that can be influenced VM effectiveness and its impact subsequently on construction project outcomes. The research ultimately is expected to provide a framework through which to understand those critical factors that most influence individuals in performing the necessary creative thinking and decision-making processes that impact on construction project delivery success. The findings were expected to benefit potential VM practitioners and organisations wishing to enhance the conducting of VM study by considering the contribution possible through harnessing the human aspects of the organisation.

The system-based frameworks with ten attributes were generated from this research. Findings from the case studies observed that project team member's composition in a VM seminar during the design process has minimal influence on improving the subsequent construction process. However, the degrees of interaction, diversity of visualisation aids, certain cultural dimensions and the system thinking approach all have significant influence in maximizing participation among project team members during the entire VM seminar during the design process. The significant outcomes of this research are expected to offer alternative perspectives for construction professionals and clients to understand the constraints and strategies to implement VM.

Generally, from the obtained results, the main reason that VM did not receive a valid application in the field of projects investment control in Malaysia lies mainly in the following areas:

(i) Lack professionals which master the knowledge of VM

When using VM, professionals should not only master the method of VM, but also understand construction technology and investment management however, the phenomenon which is widespread is that engineers do not understand the contents of investment management, and investment managers know little about the technical knowledge of construction.

(ii) Lack a special link which optimize the design scheme by VM

VM is a process which combines with technical scheme and economic evaluation. Under the current management of project design, technical scheme and economic evaluation are completed by different departments. Technical and economic professionals work relatively independent, lack a mechanism which completes the design work jointly.

(iii) Lack a system which insure the use of VM at the design stage

At present, there lack the special content which use VM to review design scheme at design phase. There isn't a corresponding service fee rules and reward system for the use of value engineering to optimize design scheme. As a result, design units have no interest to optimize design scheme and improve investment benefit by using VM.

6.4.3 Research Question 3 and 4

The VM methodology has shown a great contribution towards achievement of project objective. Hence, stakeholders have to be cautious regarding the impact of VM contribution. VM methodology has obviously provided the proof of offering professionals with a more in-depth, proactive and systematic technique in running a construction project and reduced design costs with a better understanding of client's need.

The obtainable benefit of VM process was clearly established in this research and it was shown that the resultant savings are clearly identifiable and normally reliable. In addition, the positive and optimistic influence of VM in providing a tool for establishing the project rationale was demonstrated. It was concluded that the VM process benefits the future of the construction industry by adding value. The analyses considered in this research furnished a better comprehension and understanding of the implementation of VM towards improving the project value for the stakeholders. This was done by providing new proof to the body of knowledge. In order to efficiently apply VM, serious responsibility and commitment of time and resources are required and in return, it offers advantages far in exceeding the cost such as creating a realistic factor of view for stakeholders which yields better value for money for their obtained development projects and bringing recommendations to stakeholders for putting into practice the VM viewpoint within their organization.

Performing an exploration in the issues associated with the application of VM by Perunding ZNA at the design stage resulted in a number of conclusions in response to the objectives of this research:

(i) The proposed VM algorithm can ameliorate the project design scheme by using GA optimization method to obtain the best combination, and make the project investment structure more reasonable, and achieve the goal of control project investment.

(ii) From the case studies considered, it was shown that the VM stage can give rise a cost saving ranging from 25% to 30% while deficiencies in the management and control of the VM process within the design process of the project could result in reduction of potential benefit.

(iii) Although it is possible to apply VM on each project, but more effective implication of VM studies can be performed during complex and big construction projects which involves high potential of restoring the investment.

(iv) The VM does not just target achieving the cost reduction, improving the design standards or simplification of construction and saving time and money, but also creating a balance between all the needs of the project.

(v) The implication of VM was presented parallel to company purposes. Every person that joins for VM shall be welcomed and no one in the team should think in the opposite of project management, or should be suspicious in the benefits of VM.

Perunding ZNA in Malaysia addressed the above issues to develop and validate a model for the improvement in VM implementation. This model seeks for improvements at both the design and construction stages of the projects. Regular application of VM in Malaysian construction sector will raise the systematic working and the quality as well as competition between the companies and therefore prices will become lower. By ascending the contractor quality and customer satisfaction, the Malaysian civil engineering sector will be capable of advancing much further.

By observing the interests in integrating the VM application in future projects from more than 80% of the respondents who belonged to various segments of the industry, it can be concluded that there is an encouraging result towards the future of VM in the Malaysia construction industry. According to the analysis carried out, the project manager is the best choice for VM facilitator in Malaysia. The project manager should be followed closely by the quantity surveyor. This research revealed that majority of the respondents is willing to use VM as the tool to reduce the cost. Apart from that, many respondents also required VM to develop a better project brief, identify the need for a project and to review the design. They look into VM as an opportunity to have better involvement in the projects.

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APPENDICES

Appendix A

Value Management Questionnaires

This survey is conducted by the Seminar Organiser to evaluate the current practice of VM for projects in Malaysia.

Part 1

Please tick.

1. Current profession.

   ☐ Academician ☐ Architect ☐ Engineer ☐ Management ☐ Planner
   ☐ Quantity Surveyor ☐ Others

2. Position in current company.

   ☐ Director ☐ Higher Management ☐ Middle Management ☐ Executive
   Others ☐

3. Company nature of business.

   ☐ Developer ☐ Consultant ☐ PMC ☐ Education ☐ Government Agency
   Contractor ☐

4. Highest qualification.

   ☐ Diploma ☐ Advance Diploma ☐ Degree ☐ Master ☐ PhD
   Professional Cert. ☐

5. Field of study.

   ☐ Business ☐ Engineering ☐ Management ☐ Architectural ☐ Planning
   ☐ Quantity Surveying ☐ Others

6. Working experience.

   ☐ 1 – 5 years ☐ 5 – 10 years ☐ 10 – 15 years ☐ 15 – 20 years

☐ More than 20 years

7. Years of experience in VM.

☐ No experience ☐ 1 – 5 years ☐ 5 – 10 years ☐ 10 – 15 years

☐ 15 – 20 years ☐ More than 20 years

8. Attended VM course before?

☐ Yes ☐ No

9. Which is the best profession to apply VM?

☐ Architect ☐ Engineer ☐ Project Management ☐ Planner

☐ Quantity Surveyor ☐ Contractor ☐ Others

Part 2

Please tick.

1. VM should be applied for construction projects in Malaysia.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

2. Based on my understanding, these are the benefits of VM application.

a. Can reduce project cost.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

b. Increase value to the project.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

c. Can reduce wastage.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

d. Can improve function and productivity.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

e. Innovative design.

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

f. Others:...

☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

3. Based on my experience, these are reasons of why VMis not well received in Malaysia.

   a. Lack of understanding of VM application.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

   b. Conflict of interest between stakeholders.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

   c. Lack of communication between all professions.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

   d. Lack of contractual provisions.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

   e. Difficulty in applying VM.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

   f. Others:...

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

4. VM should be included in university syllabus.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

5. There is a bright future for VM.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

6. Will consider VM in my future projects.

   ☐ Strongly disagree ☐ Disagree ☐ Neutral ☐ Agree ☐ Strongly agree

Appendix B

Interview Questions

Interview introduction

"Value management application in construction project has proven to assist construction team in making structured approach to decision making in the design of a project. The involvement of multi-disciplinary team participant in VM seminar allows for comprehensive review of the design with aim to improve construction process on-site. However, their degrees of involvement in the seminar process are influenced by the level of skills, knowledge, experience and other related factors. The aim of this interview is to explore these issues and finding practical solution to improve current design practice and hence construction process on-site."

The following are the questions:

(1) What is your purpose of attending in VM seminar?

(2) In reviewing the design for the present project, what is your perception on VM influence in improving construction process on-site?

(3) In your opinion, do you think that VM focusing on design will assist in improving construction process on-site?

(4) In what aspect does VM study can improve the design of the present projects?

(5) How does multi-disciplinary involvement in VM seminar influence design outcome of construction projects?

(6) Do you observe any limitation of multi-disciplinary participants in seminar in term of their contribution?

(7) What are the main attributes of a participant that make an effective VM seminar in reviewing the design of construction project?

(8) How do you view participant's level of knowledge/skills and experience in this seminar?

(9) What are your suggestions to improve these attributes among future participants?

(10) Considering maximizing the outcome of the VM study for construction project, what can be done in increasing contributions by participants looking into the design?

Appendix C

VM Seminar Brochure